THE

AGRICULTURAL LEDGER.

1898—No. 1.

(REPRINT FROM THE BENGAL BULLETIN No. 4)

BRASSICA SP.

(RAPE AND MUSTARD.)

[DICTIONARY OF ECONOMIC PRODUCTS, Vol. I, B. 799–855.]

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A Note by Surgeon-Major D. PRAIN, M.B., M.A, *Superintendent of the Royal Botanic Garden, Sibpur, Calcutta.*



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THE MUSTARDS CULTIVATED IN BENGAL.

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A Note on the Mustards cultivated in Bengal; by SURGEON-MAJOR D. PRAIN, *Superintendent of the Royal Botanic Garden, Sibpur.*

SECTION I.—INTRODUCTION.

THE Director of Land Records and Agriculture, Bengal, desiring to obtain accurate information regarding the mustards cultivated in the Lower Provinces, in 1895 submitted to the Superintendent of the Royal Botanic Garden some 150 different samples of their seeds. These samples were made over to the writer for examination in the ordinary way. After an attempt to arrange them with the aid of Indian works on Botany, it was found necessary to abandon the task as hopeless: the names and information supplied with the samples were self-contradictory, and in many instances irreconcilable with the statements made by Roxburgh (*Flora Indica*, iii. 117—125), Hooker and Thomson (*Journal of the Linnean Society*, v. 169—172, and again in *Flora of British India*, i. 155—157), Duthie and Fuller (*Field and Garden Crops of the North-West Provinces and Oudh*, ii. 28—34), and, finally, Watt (*Dictionary of the Economic Products of India*, i. 520—534).

The only hope of settling the difficulties that beset the enquiry seemed to lie in following for Bengal the method adopted by Duthie for Upper India—in cultivating carefully all the kinds of mustard grown throughout the Lower Provinces, and comparing them in the living state at all stages of their growth. It was too late to do this in 1895, but the Director, on being requested by the writer to call for a second set of samples, was at the trouble to do so. These samples were sown on October 22nd and October 23rd 1896, in a portion of the Sibpur Experimental Farm made over to the writer for the purpose. The plants were made the subject of study from the time of their germination till they were harvested. The present note embodies the results of this study.

The cultivation of these plants has shown that the confusion amongst the Bengal mustards is largely an affair of names and statements: as regards the plants themselves, there is little difficulty. Practically, there are but three mustards cultivated in Bihar and Bengal. These three constitute the familiar *Rai*, *Sarson*, and *Tori* crops. Each one of the three varies within its own limits to a greater or less extent: none of them shows the slightest tendency to pass from one to another. So far at least as the Lower Provinces are concerned, the existence of anything in the nature of a form intermediate between *Rai* and *Sarson*, *Rai* and *Tori* or even between the more closely allied *Sarson* and *Tori* is wholly imaginary.

Still the idea that such intermediates should exist is not altogether inexplicable. Examples of the same form sent from different districts may bear any of the three names given above, while the differences between flowering examples of *Sarson* and *Tori*, with the leaves still attached, and between fruiting examples of *Tori* and *Rai*, whence the leaves have fallen, are much less salient in herbarium specimens than in the living plants. And where three specimens of one form may be submitted for examination from three different districts under as many different native names, along with three specimens of different forms from still other districts, but with the same native name given for each, it is not to be wondered at that it should have been supposed, by more than one author, that the various forms at times pass into one another. It is hard to realize that vernacular names as applied by the natives themselves are not merely worthless for purposes of comparison, but may, if relied on, be highly misleading. Such, however, is the case; although often, perhaps indeed usually, rigidly enough applied within a given district or group of districts, native names are worse than useless when they are depended on to yield information regarding another group of districts. And yet it is inexpedient, indeed in the present instance, it is impossible, to dispense with the use of native names. It is a safe general rule, when precision is desired, to employ, in referring to any plant, what is termed its scientific name. There are, however, occasions, and this is pre-eminently one of them, when even systematic botany is fallible. The scientific names of our Indian mustards, besides being, in some cases, cumbrous and clumsy, are, in every case, even more likely to mislead—were such a thing possible—than the native names themselves. For, besides the difficulties that later writers have experienced in differentiating the Indian

mustards—many of these difficulties, it may be said in passing, would never have arisen if more reliance had been placed by his successors on Roxburgh's judgment—there are difficulties of another kind to contend with. These have arisen from the attempt to identify the various Indian mustards with European cultivated forms—an attempt which, it is to be feared, has hardly been more successful than the attempt to distinguish the mustards themselves.

The difficulties of this problem can only be satisfactorily settled by the simultaneous culture of all the Indian and all the European kinds and by a careful comparative study of the various forms at every stage of growth. Nor will this study be effective without simultaneous culture and study of the Chinese kinds among which, the writer is inclined to believe, will be found the stocks whence European and Indian forms alike have been derived. To describe the Indian mustards, and yet make no suggestion as to their probable affinities, would be obviously to avoid a portion of the task incumbent on the taxonomic botanist; in the accounts of particular mustards that follow, the writer has therefore expressed the opinion he is inclined to hold as to the probable general relationships of each. But as regards certain details, he asks for the right to retain an open mind, and he ventures to suggest to others the advisability of doing the same.

It is doubtless convenient for the District or Settlement Officer to speak or write of a particular crop as "Mustard," "Colza," or "Rape;" the names are familiar, and convey a fairly definite idea. It would, however, be safer to qualify the terms by speaking of the plants as "*Indian* Mustard," "*Indian* Colza," "*Indian* Rape"—safer still, provided the three crops can be recognisably described, to speak of them simply as "Rai," Sarson," and "Tori," respectively, and, as far as possible, to avoid the use alike of the European popular and scientific names.

Rai, or Indian mustard, there is not any doubt, is the [illegible]*sa*, and [illegible] *juncea*. [illegible] Linnean [illegible] to the qualities of the plants—though in each case the name and note are quite accurate—have been transferred from *Rai* to *Sarson*, and *vice versâ*. The botanist has, of course, merely to read the technical descriptions of the plants to detect the transfer of the notes; but the result has been that every *non-botanical* consultant of the paper in question has gathered

that the scientific name of *Rai* is *Brassica campestris*, and that *Brassica juncea*, which really is the name of *Rai*, is the scientific term for *Sarson*.

Then, *Sarson* and *Tori* are certain to be misunderstood if their scientific names are used. Both are, as a rule, referred [illegible] ever seen [illegible] say that [illegible] ind them treated in botanical works as merely different varieties of one particular sub-species of *Brassica campestris*. Roxburgh, who knew the two crops, treated them as distinct species, naming the former *Sinapis glauca*, the latter *Sinapsis dichotoma*. But Roxburgh, usually so accurate, has somewhat confused the names of the two: he gives the name of the first as *Shwet Rai* (white mustard), of the second as *Shorshi* or *Shorshi*. This is exactly what the two *are* called in Central Bengal, and so far, therefore, all is well. But he gives the Hindi term *Sarson* as the equivalent of the Bengali [illegible] *Tori*. This precisely [illegible] *Sarson* is *never* applied [illegible] l is termed *Sarisha* (or *Shorshi*, as Roxburgh spells it), but always to the plant that in Bengal is termed *Shwet Rai*. Roxburgh's third name for *Tori* is *Sala Rayee*,—a mere *lapsus calami* for *Salharan*, which has escaped the notice of the editor of the volume.

The nice academic questions involved in deciding what constitutes a species, sub-species, or variety are fitly discussed in monographs of natural families. But in notes like the present, purely economic in scope, such refinements tend only to confusion. When the layman, in the course of business or duty, is brought face to face with two plants so dissimilar in appearance, mode of growth, time of ripening, and method of cultivation, and so completely wanting in anything of the nature of intermediate forms, as *Sarson* and *Tori* are; and when, on turning to a botanical work, he finds it stated that they are the same thing, or at most only *different varieties of the same thing*, he is apt to wonder at systematic botany. Even if he appreciates the precise meaning of the expression, it is too much to expect that he shall care to write or speak of *Brassica campestris*, subsp. *genuina*, var. *glauca*, and *B. campestris*, subsp. *Napus*, var. *dichotoma* when he can use the terms *Sarson* and *Tori* instead. Indeed, it is well for all concerned to cultivate this frame of mind, for to follow the botanical arrangement accorded to these mustards is trying either to reason

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or to faith. Systematic botany, not content with first denying that *Tori* and ordinary *Sarson* differ, insists that *Ulti Sarson*, which is unlike ordinary *Sarson* only in having pendent pods, is a separate species (*Brassica 3-locularis*), and further declares that if the pods of ordinary *Sarson* have 4 rows of seeds instead of two, it constitutes still another species (*B. 4-valvis*); statements that amount to declaring two equal and similar parts to be, if taken conjointly, rather less, if taken separately, each of them greater than the whole.

On account of the confusion just outlined, and it may be remarked that this sketch is far from exaggerating the tangle that exists, the writer has given an altogether subordinate value to the scientific names of the plants, and has employed the leading vernacular ones to designate the various mustards themselves, regarding which, *as plants*, no doubt is possible.

The present note does not deal with the mode of cultivation, acreage under crop, outturn of, or trade in, the mustards and their oils in the various parts of the Lower Provinces. It deals merely with the botanical characters of the various [illegible] each other and to [illegible] Bengal. Plates are [illegible] nd maps are employed to explain the distribution of the kinds and of the names used to designate them.

Besides the examples of *Rai*, *Sarson*, and *Tori*, of which the writer has had respectively 46, 45 and 48 plots under cultivation, there were two others—one from Chittagong and one from Kalimpong in British Bhutan—that proved quite distinct from any of the three, and that call for separate description.

One of these—the Kalimpong *Rai*—possessed the great interest of being *Sinapis rugosa*, a Roxburghian plant that [illegible]

Roxburgh as *Sinapis cuneifolia*, which has been equally lost sight of and which the Department of Land Records and Agriculture had not communicated. The search did not result in the re-discovery of *S. cuneifolia* but was the means of disclosing yet another form most nearly allied to, but quite distinct from, *Tori*. Hardly had this information been received from Sikkim when Dr. Watt, Reporter on Economic Products to the Government of India, returned

from an official tour in North Bengal with the interesting information that the cultivation of what is perhaps the lost *Sinapis cuneifolia* prevails throughout the area occupied by the populations of Cachari or Rajbansi origin, *i.e.*, through-

compulsory

Neither Europe are grown of the Lower Provinces. No description, therefore, is given of either of those kinds. Since, however, they may occasionally be met with in the gardens of the curious, and as both should be familiar to officers of European experience, a place has been given to them in the Key.

SECTION II.—BOTANICAL ACCOUNT OF THE MUSTARDS OF BENGAL.

The mustards belong to the genus *Brassica* Linn., of the natural order *Cruciferae*, one of the most important genera in the vegetable kingdom, including as it does the varied forms of Mustard, Rape, Colza, Turnip and Cabbage. The present note does not deal with the Cabbage or the Turnip, both of which are quite exotic in the Lower Provinces, and only treats exhaustively those Colzas, Rapes and Mustards that form staple field or garden crops within the area under the rule of the Lieutenant-Governor of Bengal.

Following a brief technical description of the genus will be found a key to the species in this area. This key, in turn, is followed by a more detailed account of each of the species, varieties, cultivated races, and special forms to be met with in Bengal, the geographical distribution of each by districts and the names borne by each in the different districts being added. In arranging these districts it has not been found advisable to adhere to the present political divisions of the Lower Provinces. However convenient these may be from the administrative point of view, they do not always accord with natural facts. The deviations, however, have not been

of the Kosi, north of the Ganges and west of the Brahmaputra; and (3) East Bengal,—the Dacca Division. Eight or more less natural areas are thus obtained, viz., Tirhut, South Bihar, Chota Nagpur, Orissa, West Bengal, North Bengal, East Bengal, and Chittagong. In giving the distribution of the various mustards the regions are noted in the above order.

BRASSICA Linn.

The Mustards, Rapes, Turnips, and Cabbages.

Annual, biennial, or perennial herbs, either smooth or with stiff or rough hairs; the lower leaves usually deeply pinnate or lyrate, the upper ones often entire; the flowers yellow. *Pod* linear, cylindric, or nearly so, more or less beaked at the top beyond the end of the valves; the beak consisting either of the conical style alone or including a portion of the pod itself, and then often with one or more seeds in it. [illegible] ...ttened; the seed-leaves [illegible] forms, many of them, [illegible] races fixed under cultivation; the actual number of species probably not more than 80—90. The genus is a native of North Temperate regions, with apparently two centres of origin—an Oriental-Mediterranean and a Chinese. Under cultivation some of the forms reach, as cold-season crops, sub-tropical and even tropical districts.

There is only one Indian species that is not given in the subjoined key; it is excluded because it does not occur within the limits of Bengal. This species, *Brassica Tournefortii* Gouan, is a member of the group that has originated in the Oriental or Mediterranean areas; it is stated to have been once found in the semi-desert country between Ajmir and Delhi, and is, according to Edgeworth, cultivated in Western Tibet. From these points it extends westward to Italy and Spain, but does not come farther towards the East.

Key to the Mustards.

* Pods pressed closely against the axis of the raceme, beak small; pods slender, short and smooth ... ... BLACK MUSTARD.

** Pods spreading away from the axis of the raceme, beak long:—

† Pods hairy, rather shorter than the flat beak WHITE MUSTARD.

†† Pods smooth, longer than the conical beak:—

‡ Leaves of the stem all narrowed to the base, not clasping the stem:—

[illegible]

leaves never lyrately lobed:—

¶ Margin of leaf deeply irregularly toothed, midrib very much expanded and thickened; *leaves green* ... ... *Paṡlí.*

¶¶ Margin of leaf slightly finely crenate or almost entire, midrib narrower, leaves covered with bloom .. ... *Láhí Sáo.*

§§ Stems elongating from the commencement of growth; leaves at the base quickly withering; most of the stem-leaves lyrately lobed *Ráí.*

‡‡ Leaves of the stem all wide at the base, at least the upper ones clasping the stem:—

§ Stems elongating from the commencement of growth, leaves at base quickly withering, all the stem-leaves clasping the stem:—

¶ Leaves with hairs, at least when young, densely covered with a pale greyish bloom:—

† Root stout spindle-shaped, woody; pods slender, beaded opposite the seeds ... CHITTAGONG "MUSTARD."

†† Root slender, tapering; pods stout, not beaded opposite the seeds ... SARSON.

¶¶ Leaves without hairs, green above, with a faint bloom beneath, *smaller and less* lobed:—

† Root slender, tapering, woody ... ... TORI.

†† Root stout, turnip-shaped, esculent ... ... BHUTIA RÁÍ.

§§ Stem short till the flowering shoots form, leaves at the base persisting to form a loose cabbage; only the uppermost stem leaves clasping the stem PAK-CHOI

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A.—BLACK MUSTARD.

BRASSICA NIGRA *Koch in Roehl. Deutschl. Flora*, ed. iii. iv. 713; *H.f. & T. Journ. Linn. Soc.*, v. 156; *Flor. Brit. Ind.*, i. 156; *Watt Dict.*, i. 530.

B. sinapoides *Roth. Man.*, ii. 957.

Sinapis nigra *Linn. Sp. Pl.*, 668; *DC. Prodr.*, i. 218; *Wall. Cat.*, 4790.

S. erysimoides *Roxb. Hort. Beng.*, 48; *Flor. Ind.*, iii. 123.

This, the true mustard, is not cultivated in Bengal, and indeed is very little grown or known anywhere in India.

The flour obtained by grinding the seeds, imported and known as "Europe Mustard," is used as a condiment by

mustard is paler than French mustard. But it also explains why the best English mustard *is* of such poor quality as compared with French mustard, the flavour and pungency of mustard residing largely in the husk. The reason why the husk is removed from English mustard is mainly a trade custom: the trouble is taken, it need hardly be said, more in the interest of the dealer than of the consumer. The paler colour enables the admixture of "white-mustard" flour, which is commercially a much inferior article, to take place without giving rise to inconvenient questions. And in the case of some English mustards what first catches the eye on opening a box is a printed declaration to the effect that the contents are a mixture of pure mustard with farina and choice condiments. What the '*choice condiments*' may be, the writer does not know.

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"Indian" mustard (*B juncea*), and of the Bengali name *râi sarisha*, the use of which is also strictly limited to *râi* or "Indian" mustard (*B. juncea*). From the absence of any really distinctive name it may be safely concluded that

"black mustard" is an article late of introduction into India; the fact that the Persian form of the general name (*Sárshaf*, the name by which it is known in Indian hospitals), is the only Indian term that is at all distinctive, helps to support this conclusion. But it does not necessarily follow from this, as some are inclined to think "that the ancient Sanskrit writers had not seen the true black and white mustard, and that the word *rájiká* may have originally denoted a form of *Brassica juncea* and the word *siddhártha*, a form of *B. campestris*" (Watt, *Dict. Econ. Prod.*, i. 532). Dr. Watt adds:—"Nowadays these names are chiefly applied to the true black and white mustard—*B. nigra* and *B. alba* respectively." As regards the latter statement, the facts in Bengal are widely different. The Sanskrit *siddhártha* in the Lower Provinces connotes *Çvéta* or white-seeded *Sarson*, while *rajiká* connotes *Rái*. As regards the former, the conclusion to which the facts of the case would lead seems also precisely the reverse. If the Sanskrit-using races entered India by the north-west, they must have done so through regions where both the black and the white mustards still grow, but eastward from which neither form has yet extended. There is every indication that both *Rái* and *Sarson* are immigrants from China by a north-eastern route and that their arrival has been independent of any Aryan incursion. Nothing, then, is more probable than that in *Rájiká* and *Siddhártha* we really have Sanskrit terms *originally* applied to the black and white mustards respectively; afterwards transferred, as the language and those who used it passed eastward, to plants in the new region more or less representative of those that bore these names in the abandoned one.

B.—WHITE MUSTARD.

BRASSICA ALBA *Boiss. Voy. Espagne*, ii. 39; *H. f. & T. Flor. Brit. Ind.*, i. 157; *Watt, Dict.*, i. 521.
Sinapis alba *Linn. Sp. Pl.*, 668; *DC. Prodr.*, i. 220.
S. foliosa *Willd. Enum.*, 668; *DC. Prodr.*, i. 220.

For this also Dr. Watt gives a large number of vernacular names; that quoted as the Bengali equivalent is *Dhóp-rái*. As will be seen under *Sarson*, this name is exclusively applied to a form of that plant, and never apparently to *B. alba*, which, as a matter of fact, was not sent from any part of the Lower Provinces.

This appears to be even rarer in India than black mustard.

C.—PASAI, PALANGI, OR PAHARI RAI; BADISHA LAI, OR BHOTIYA LAI.

BRASSICA RUGOSA *Prain.* [B. rugosa VAR. typica *Prain.*]

B. juncea *H. f. & T. Journ. Linn. Soc.*, v. 170; *Flor. Brit. Ind.*, i 157 *in part, excluding the* RÁI *plant and also excluding* Sinapis cuneifolia *Roxb.*

B. chinensis *Duthie & Fuller, Field and Garden Crops*, ii. 34, *not of Linn.*

[B. dentata, *Watt Mss.* (B rugosa VAR. agrestis *Prain.*)]

Sinapis rugosa *Roxb., Hort. Beng.* 48; *Flor. Ind.*, iii. 122.

Moutarde de Chine à feuille de Chou—*Vilmorin, Les Plantes potagéres*, 356.

A cold-weather crop in the Western, Central, and Eastern Himalaya of annual herbs with very short stocks till the plants begin to flower, and with permanent radical leaves, [illegible]

its branches ascending to form a narrow pyramidal head 6–10 in. across. *Root* slender, tapering, 6 in. long. *Leaves* very large, the blades of the basal, cabbage-forming ones, which are disposed in a condensed spiral, 12–15 in. long, 8–9 in. wide, obovate obtuse or subacute, when young hirsute above, the anterior half-margin toothed, the posterior much laciniate and tapering to a stalk 3–4 in. long, 1–1·5 in. wide, thick, white and fleshy, continued into the leaf as a broad, white fleshy main-nerve with longitudinal ridges and weak bristles beneath, and breaking fan-wise beyond the middle into many slender white sub-equal veins, the blade proper bright green, and without bloom. *Stem* branching, as soon as it shoots, from the axils of all the leaves above those of the stock; the stem-leaves similar to the basal ones but smaller, decreasing upwards, all without stalks and never stem-clasping; the branches also leafy, but more slender and shorter than main stem, their leaves smaller and less laciniate towards base, sub-acute at the tips, and with again smaller branches in their axils. *Flowers* in short corymbs, about 1·5 in. long when the lowest flower opens, subsequently elongating into racemes 8 in. long, with equal slender stalklets ·6–·7 in. long, slightly spreading, but not elongating in fruit, without bracts or bractlets.

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Sepals slightly spreading, ·2 in. long, ·08 in. wide, still green at time of falling. *Corolla* ·6 in. across, petals with a pale-green, narrow claw ·12 in. long, and a bright-yellow, spreading, regularly obovoid blade ·25 in. long and ·2 ... beneath. *Pods* 2-valved, ... long, ·2 in. thick; beak ... valves convex, rigid, thinly leathery, faintly beaded opposite the seeds, with a strongish midrib prominent outside, and with rather distinct looped veins on each half-valve. *Seeds* 7—10 under each valve, spherical, brown, finely rugose, hilum the colour of the remainder of the testa; cotyledons yellow.

DARJEELING DISTRICT: Kalimpong (*Rát*)! Rungbee, etc., 2—6,000 feet (*Pasái*, *Paangi* or *Pahari Rát*)!

The cultivation of this plant appears to be usual in Nepal, whence Buchanan-Hamilton sent seeds of it to the Calcutta Botanic Garden in 1802. Hamilton informed Roxburgh that the seeds came from Tibet; Nepalese settlers have carried ...

and it is not impossible that a Chinese plant referred to by Forbes and Hemsley as a variety of *B. juncea* (*Journ. Linn. Soc.*, xxiii. 47), which is "cultivated in immense quantities, and after drying in the sun is pickled and eaten with rice," may be the same. It is, however, just as likely to be the next one.

This, Mr. Pantling notes, is cultivated both as a vegetable ... ds. When ... Vilmorin's ... early cold-weather crop in the hills, and is grown more for the leaves than for the seeds. The leaves are plucked almost as fast as they are developed, so that by the time the flowers are pro-...

... ther ... of ... ian ... its reduction, unless as a sub-species, to *S. juncea*. It is, as we know, highly probable that India owes *S. juncea* (the *Asl-Rát*) to China, and it seems likely that the route followed by the *Asl-Rát* on ... across the ... At all even ... Roxburgh, ...

botanically separable from his *S. juncea*, is far commoner along that route than it is in the plains of India.

But *B. rugosa*, if it be a derivate of the stock from which *B. juncea* has originated, is a derivate of long standing. Not only has it probably originated in China and been introduced in its present form to the Central Himalayan region through Tibet, in India, at all events, it shows no inclination to revert to a form approaching *B. juncea*. On the contrary, we are indebted to Dr. Watt for the interesting discovery that in Manipur there is an "agrestal" plant, for which he has proposed the name *B. dentata*, which, though quite wild, is not botanically separable from Roxburgh's *Sinapis rugosa*, and which we cannot by any stretch of the imagination identify with Roxburgh's *Sinapis juncea*. In other words, *B. rugosa* cannot be included in *B. juncea* even as a separate variety. It constitutes what may be termed a species of secondary rank, or a sub-species, according to the standpoint from which the problem is viewed. In a monograph of the genus *Brassica* it would doubtless be sufficient to treat *B. rugosa* as a sub-species related to *B. juncea*, precisely as *B. Napus* and *B. Rapa* are related to *B. campestris*. In a note like the present it is obviously better to treat it, just as *B. Napus* and *B. campestris* are treated, as a distinct species. The precise relationship is shown in the systematic conspectus that follows this chapter.

The most interesting feature about *B. dentata* Watt (*B. rugosa* VAR. *agrestis*), is that it combines exactly the foliage of true *B. rugosa* with a somewhat different habit of growth, the root-leaves forming a rosette rather than a cabbage.

EXPLANATION OF PLATE I.

BRASSICA RUGOSA Prain.

(Sinapis rugosa *Roxb*)

1. Plant before flowering, about $\frac{1}{12}$, *after Vilmorin*.
2. Portion of stem after flowering has commenced, with stem-leaf, $\frac{1}{4}$; *reduced from Roxburgh's original drawing*.
3, 4. Portions of a flowering branch, $\frac{1}{2}$; *from Roxburgh's original drawing*.
5. Unripe capsule, $\frac{1}{2}$; *from Roxburgh's drawing*.
6. Ripe capsule, $\frac{1}{2}$; *from Roxburgh's drawing*.
7. Seed; enlarged; *from Roxburgh's drawing*.

D.—LAHI SAG.

BRASSICA RUGOSA var. CUNEIFOLIA *Prain.*

B. juncea *H. f. & T. Journ. Linn. Soc.*, v. 170; *Flor. Brit. Ind.*, i. 157, *in part; excluding the* ASL-RÁI *plant and also the synonym* Sinapis rugosa *Roxb.*

Sinapis cuneifolia *Roxb. Hort. Beng.* 48; *Flor. Ind.*, iii. 122.

A cold-weather garden crop, in Northern Bengal and in Assam, of annual herbs with tall much-branching erect stems 4–6 feet high, the branches ascending to form a wide pyramidal head 1·5–2 feet across. *Root* stout, swollen, 6–8 in. long. *Leaves* large, the basal ones soon withering, their blades 12–15 in. long, 4–6 in. wide, obovate, the point subacute, tapering from beyond the middle to a stalk 2 in. long, ·35 in. wide, channelled above, not ridged, continued into the leaf as a slender tapering midrib, giving off at intervals 10–12 pairs of lateral nerves, glabrous above even when young, with very few bristles beneath, the blade proper glaucescent, the margin finely serrate. *Stem* branching from the axils of the 4th or 5th leaf upwards, these stem-leaves similar to the basal, but smaller, decreasing upwards; all without stalks, and never stem-clasping; branches always leafy, nearly as strong and long as main stem, and often again branching; stem and branches with a slight bloom, and more or less tinged with purple, especially near the nodes. *Flowers* in short corymbs, about 1·5 in. long when the lowest flower opens, subsequently elongating into racemes 5–6 in. long, with equal slender stalklets ·4–·5 in. long, slightly spreading but not elongating in fruit, without bracts or bractlets. *Sepals* slightly spreading, ·2 in. long, ·08 in. wide, still green at time of falling. *Corolla* ·5 in. across, petals with a pale-green, narrow claw ·15 in. long and a bright-yellow, spreading, suborbicular blade ·2 in. long and broad, very faintly veined. *Pods* 2-valved, including the beak 1·25–1·5 in. long, ·2 in. thick; beak narrowly conical, ·25 in. long; valves convex, rigid, thinly leathery, faintly beaded opposite the seeds, with a strongish midrib prominent outside, and with rather distinct looped veins on each half-valve. *Seeds* 7–10 under each valve, spherical, brown, finely rugose; hilum the colour of the remainder of the testa; cotyledons yellow.

Like the preceding, this was sent to the Calcutta Garden from Nepal by Buchanan-Hamilton in 1802, and, as in the other case (so, at least, Roxburgh notes) Hamilton got

the seeds from Tibet. However, there is no trace of the cultivation of this kind among the Nepalese settlers in the Eastern Himalaya at the present time, and there is just the possibility of some mistake as to the locality whence the seeds came, because this appears to be one of the staple crops in Dinajpur, Rangpur, and Bogra—districts that were carefully economically surveyed by Buchanan-Hamilton at the beginning of the century, and whence it is possible the seeds may have been obtained. Its cultivation also extends, Dr. Watt finds, into the valley of Assam, and if limited to, seems to be co-extensive with, the area occupied by races that are of a Cachari, or, as in North Bengal they are usually termed, a Rajbansi stock

It is a garden, not a field, crop. This may explain why the Department of Land Records did not communicate seeds. Dr. Watt's field-notes describe the cultivation of the plant and the use of its leaves in terms identical with those used by Mr. Pantling in describing the culture and use of *B. rugosa.*

This plant, Roxburgh's *Sinapis cuneifolia*, has been reduced, like the preceding, by Hooker and Thomson to *Brassica juncea.* It is nearest, of the Indian forms, to *B. rugosa;* the flowers and fruits and seeds are practically identical with those of *B. rugosa*, and differ, especially the fruits, rather markedly from those of *B. juncea.* But the swollen root, the glaucescent stem, and the rather smaller petals seem to indicate that this is at least varietably separable. No agrestal form of this, corresponding to *B. dentata* or *B. patens*, has been met with as yet.

Hooker and Thomson, and again Forbes and Hemsley (*Journ. Linn. Soc.*, xxiii. 47) have reduced *Sinapis chinensis* (Linn.) to *B. juncea.* [illegible]
identify *S. chinensis* (L[illegible]
rugosa Roxb ; this, in e[illegible]
reduced *S. rugosa* to *B. juncea*, is not quite the same thing. The matter must be left for the present as somewhat doubtful. Linnaeus and Willdenow both state that *Sinapis chinensis* has small *white* flowers; either reduction must therefore have been put aside as 'suspicious,' were it not for the fact that De Candolle notes (*Prodr.*, ii. 219) having actually seen a specimen of *S. chinensis* in the Paris Herbarium, and says that its flowers are very like those of *S. juncea.* If one or other of the reductions be necessary, it seems as if that proposed by Hooker and Thomson, not that proposed by Duthie and Fuller, must be the correct one. In any case, even if the identification indicated by Duthie and

Fuller could be sustained, the name *Brassica chinensis* proposed by them is not available. There is already a different *Brassica chinensis* Linn. (the China Cabbage), older as a name than the same author's *Sinapis chinensis*.

EXPLANATION OF PLATE II.

BRASSICA RUGOSA *var.* CUNEIFOLIA Prain.

(Sinapis cuneifolia *Roxb.*)

1. Radical leaf, ½; *reduced from Roxburgh's original drawing.*
2, 3. Portions of a flowering-branch, ½; *from Roxburgh's drawing.*
4. Flower, ½; *from Roxburgh's drawing.*
5. Unripe capsule, ½; *from Roxburgh's drawing.*
6. Ripe capsule, ½; *from Roxburgh's drawing.*
7. Seed, enlarged *from Roxburgh's drawing.*

E.—ASL-RÁI OR INDIAN MUSTARD.

BRASSICA JUNCEA *H. f. & T. Journ. Linn. Soc.* v. 170; *Flor. Brit. Ind.* i. 157; *Forbes & Hemsl Journ. Linn. Soc.*, xxiii. 47; *Duthie & Fuller, Field and Garden Crops*, ii. 33; *Watt, Dict.*, i. 528.
Sinapis juncea *Linn. Sp. Pl.* 668; *DC. Prodr.*, i. 218; *Franch. Pl. David.* i. 40.
S. ramosa *Roxb. Hort. Beng.*, 48; *Flor. Ind.*, iii. 119.
S. chinensis *Linn. Mant. Pl.* 95; *Arduin, Sp.* i. 23, t. 10; *DC. Prodr.*, i. 219: *not* Brassica chinensis *Linn.*
S. patens *Roxb. Hort. Beng*, 48; *Flor. Ind.*, iii. 124 (Brassica juncea VAR. agrestis *Prain*).

A cold-weather crop in the plains and in the lower Himalaya of tall, annual, much-branching erect herbs 3–6 feet high, the branches ascending and forming a wide pyramidal head 1–1·5 feet across. *Root* slender, tapering, 6 in. long. *Leaves* large, the blades of the basal 6–8 in. long, 2–4 in. [illegible] 1-2 in. long, decreasi[illegible] of the stem 2–2·5 in[illegible] bright green and wi[illegible] axils of the 4th or [illegible] long [illegible] n again branching, usually [illegible] especially near the joints; [illegible] mmences oblanceolate with

an acute tip and a narrowly cuneate base, gradually tapering backwards from the middle. Flowers in short corymbs about 1 in. long when the lowest flower opens, subsequently elongating into a raceme 8 in. long, with equal slender stalklets ·6–·7 in long, without bracts or bractlets, slightly spreading and increasing, as the fruit ripens, to 2 in. in length. *Sepals* slightly spreading, ·2 in. long, ·08 in. wide, green, becoming yellowish before falling. *Corolla*
w claw ·12 in.
obovoid blade
eined beneath.
Pods 2-valved, including the beak 2·25–2·5 in. long, ·2 in. thick; beak narrowly conical, ·4 in. long; valves convex, rigid, thinly leathery, distinctly beaded opposite the seeds, with a straight strong midrib, prominent outside, and with rather strong prominent looped veins on each half-valve. *Seeds* about 20 under each valve, spherical, brown, finely rugose; hilum the colour of the remainder of the testa; cotyledons yellow.

There are three more or less distinct forms of *Asl-rái* cultivated in the Lower Provinces. They are quite easily distinguished when growing side by side, but the characters are not very tangible except in the living plant, and are certainly not of varietal, perhaps hardly even of racial value. The forms are—

1. TALL LATE RÁI; genuine *Rái*. *Leaves* near base of

beneath. *Stems* 3–4 feet high, green or very faintly purple; fruit *ripening* in beginning of February.

Cultivated fairly generally in the central part of the Lower Provinces. Samples have been received from South

hairs beneath. *Stems* 3–4 feet high, more darkly purple than in the other two forms; fruit *ripening* in beginning of February.

Much more limited even than the preceding, though apparently fairly commonly cultivated in Tirhut, South Bihar, and Western Bengal. It appears to be unknown in North and East Bengal and in Orissa, and practically unknown in Chittagong, for the only sample sent from that district was a mixture of this and of "Rough early." It is also practically unknown in Chota Nagpur, the only sample sent from that Division being a mixture of this "Smooth early" form and of *Sarson.*

As a whole, *Rái* may be said to be a general crop everywhere in the Lower Provinces, except Chota Nagpur, where it is practically unknown, and Chittagong, where it may have been only recently introduced. The explanation doubtless is that in Chota Nagpur *Tori* (there termed *Lutni*) replaces *Rái*: in Chittagong *Asl-Rái* appears to be replaced by a

…es *Juni-rái* as the ve… find, eighty years afterwards, that this name is still used within twenty miles of the Royal Botanic Garden; it is, however, curious that the name is not reported from any but the Hooghly district. Roxburgh has writt…

Sinapis ramosa in his …

note:—"The same …

Toree" By the time the manuscript of the *Flora Indica* … ascertained what the

have been transposed in Hooker and Thomson's account of the Indian *Brassicas*, much to the discomfiture of non-botanical consultants of the paper.

Sinapis patens, Roxb., properly given as *Beel-rái* in the *Hortus Bengalensis*, by an error of the printer *Keel-rái* in the *Flora In*… cultivation in Bengal which Hooker and … ginal paper … authors say … it under *Nas*… and Thomson proposed is a … there is not a single essen… can be separated from *Rái*. … fectly certain that this is … fields from dropped seeds, an… this does not represent the original wild stock whence *Rái* has

been derived; it appears to be rather a degenerate subferal escaped condition of the cultivated *Rái*. One of its most marked peculiarities as compared with *Rái*, besides its smaller size, is the habit it has acquired of appearing during the rains, though it does not flower till the cold season. The plant does not appear to extend further west than Central [illegible] gal it is far from [illegible] ie Kachin Hills, [illegible] there it flowers from March to May. It is probable that the *Sinapis chinensis* of Linnaeus and of Arduin is this particular form.

The writer therefore proposes to treat *Sinapis patens* as a distinct retrograde variety of *Rái*; it may be best known as *Brassica juncea* VAR. *agrestis*. It has already been pointed out that Dr. Watt has discovered in Manipur a similarly distinct retrograde variety of *Brassica rugosa*, occurring in fields as a weed of cultivation.

The detailed distribution of the three forms of *Asl-rái* cultivated in Bengal, as shown by samples sent to Sibpur, is given in the subjoined table along with the names that accompanied each sample. The general distribution is indicated in MAP I, SECTION A. The following special remarks are called for in connection with this list:—

The sample sent as *Rái* from Singhbhum was a mixture in almost equal parts of *Rái* and *Sarson*. Only one other sample was sent as *Rái* from any part of Chota Nagpur. It came from Hazaribagh; it proved to be *Tori*, not *Rái*.

The "small *Rái*" of Chittagong, of which only one sample was sent, consisted of about equal parts of rough and smooth short *Rái*. They ripened, however, rather later than any of the plots of either kind, and were about as 'late' as the tall *Rái* of the first column. The *Rái sarisha* of Midnapore was also a mixture of the two short forms. Both, however, ripened early. Another sample from Midnapore of clean 'short, smooth, early' had a distinctive name. The term *chota*, applied to the sample from Orissa, had reference t[illegible] a form of [illegible] Farm were [illegible] io district of origin. They were in every case rather smaller than the original seeds supplied from Tirhut or South Bihar, but not than those sent from Bengal Proper and Orissa.

DETAILS OF SAMPLES OF *RÁI.*

Cultivated at Sibpur Experimental Farm, 1896-97.

	Tall, slightly rough, late.	Short, rough, early.	Short, smooth, early.
TIRHUT.	Saran ... *Rái* or *Lahi !* Muzaffarpur ... *Rái !*		
			Darbhanga .. *Tori !* N. Bhagalpur (Supaul) *Ráichi Rái !*
S. BIHAR.	Shahabad (Bhujpur) ... *Rái !*	Shahabad (Bhojpur) .. *Lalli Tori !* " (Arrah) ... *Diarah Rái !*	Shahabad (Bhojpur) ... *Langri !* " (Arrah) .. *Lotni Rái !*
	Patna ... *Rái !*	Gaya ... *Rái !*	
	Monghyr ... *Gota* or *Tori !*		
CHOTA NAGPUR.			[Singhbhum (see note) *Rái !*]
ORISSA.	Angul ... *Chota sarisha !*		

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grown at Sibpur.

W. Bengal.	Sonthal Parganas ... *Rái* Hooghly (Serampore) ... *Kala sarisha !* " (Jahanabad) ... *Jhuni !* Jessore ... *Rái !* " ... *Maghi sarisha !*	Sonthal Parganas ... *Gota !* Bankura ... *Lotni !* Midnapore ... *Rái sarisha !* 24-Parganas ... *Kazli sarisha !* Burdwan ... *Rái !* " .. *My or Maghi !* Murshidabad ... *Taro sarisha !*	Sonthal Parganas ... *Man sarisha !* Midnapore ... *Moria sarisha !* Nadia . *Rái !*
N. Bengal.	Purnea ... *Ráichi !* Jalpaiguri (Phulkota) *Rái !* Rangpur ... *Rái sarisha !* Rajshahi ... *Rái !* Malda ... *Rái !* Pabna ... *Rái !*	Purnea ... *Rái !* Jalpaiguri (Deviganj) *Rái sarisha !*	
E. Bengal.	Dacca ... *Rái sarisha !* Faridpur .. *Rái sarisha !* Mymensingh (Sadar) ... *Rái sarisha !* " (Jamalpur) *Lá sarisha !* " (Netrakona) *Moghlai sarisha !* Backergunge (Habiganj) *Rái sarisha !* " (Burnadi) *Kala sarisha !*	Tippera ... *Rái sarisha !* " ... *Moghlai sarisha !*	
Chittagong.		[Raojan tahsil ... "Small" *Rái !*]	[Raojan tahsil; ... "Small" *Rái !*]

EXPLANATION OF PLATE III.

BRASSICA JUNCEA Hook. fil. & Thoms.

(Sinapis ramosa *Roxb.*)

1. Radical leaf, ½; *reduced from Roxburgh's original drawing.*
2. Portion of stem with leaf and branch, ½; *from Roxburgh's drawing.*
3. Flowering branch, ½; *from Roxburgh's drawing.*
4. Fruiting branch, ½; *from Roxburgh's drawing.*
5. Capsule, ½; *from Roxburgh's drawing.*

F.—COLZA, OR CHITTAGONG "MUSTARD."

BRASSICA CAMPESTRIS *Linn. Sp. Pl.*, 666; *DC. Syst. Veg.*, ii. 592; *Eng. Bot.* t. 2146.
B. campestris VAR. oleifera *DC. Prodr.*, i. 214.

A cold-weather crop, only reported from Chittagong, of tall annual herbs 4–5 feet high, branching freely from the axils of the radical leaves in a wide bushy head 2–3 feet across. [illegible]
1–1·5 i [illegible]
upper [illegible]
radical and those of the lower half of stem lyrate-pinnatifid, 6–14 in. long, the end lobes ovate-cordate 3–4 in. long, 2–3 in. wide, the other lobes along the slender petiole-like main-nerve very small; in the upper third of stem oblong lyrate-sinuate 2·5–3 in. long—all to the very base lyrate and stem-clasping, pale [illegible]
with some hairs beneath. [illegible]
all again freely branche[illegible]
especially at the joints. [illegible]
2 in. long when the [illegible]
[illegible] o 1·5 in.,
[illegible] pair ·25 in. long, exceeding outer ·2 in. long, all ·15 in. wide, glaucous, becoming yellow before falling. *Corolla* ·4 in. across, petals with a yellow claw ·15 in. long and a bright yellow obovate, ascending blade ·25 in. long, ·2 in. wide. *Pods* 2-valved, including beak 2·25–2·5 in. long, ·2 in. thick; beak slender, conical, ·5 in. long; valves convex, thinly leathery, distinctly beaded opposite the seeds; nerves outside rather slender and indistinct. *Seeds* 15–20 under each valve, spherical, bright brown, smooth; hilum the colour of the remainder of testa; cotyledons yellow.

CHITTAGONG: (*sent simply as "Mustard."*) !

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Colza.

This is the only plant among the samples sent to the Sibpur Farm that does not accord with any of the mustards mentioned or described in Indian works on Botany. The sample was a mixed one; the plot produced the above plant, and the more dwarf and early form of *Tori*, in about equal amount. It would almost seem as if mustard cultivation were of recent introduction in the Chittagong district, and it would be interesting to ascertain how it chances that [illegible] found its way into [illegible] ihar.

[illegible] '-like plants were annual, flowering freely and producing an abundance of seed, their [illegible] tem- perate env[illegible] ndeed they had [illegible] bit so usual in true Colza, and so characteristic of the cultivated Navews and Rutabagas, and of the turnips both Swedish and genuine. Indeed, till such time as the flowering branches begin to appear in the axils of its radical leaves, this Chittagong plant resembles so closely, both in foliage and in root, the corresponding stage of the Swedish turnip (*Brassica campestris* var. *napo-brassicata*) commonly cultivated in Northern Europe, that the writer was inclined to

EXPLANATION OF PLATE IV.

Brassica campestris Linn. *var.* oleifera DC.

1. Plant before flowering, about $\frac{1}{8}$; *from an example cultivated at the Sibpur Experimental Farm, raised from seed received from Chittagong.*
2. Radical leaf, $\frac{1}{3}$; *ditto.*
   Secondary branch again branching, $\frac{1}{2}$; *ditto.*
4. Flowering branch, $\frac{1}{1}$; *ditto.*
5. Flower before fully opening; $\frac{4}{1}$; *ditto.*
6. Fully-opened flower, half cut away, $\frac{4}{1}$; *ditto.*
7. Two of the longer stamens, $\frac{4}{1}$; *ditto.*
8. Young fruit, $\frac{1}{1}$; *ditto.*
9. Ovule, enlarged; *ditto.*
10. Capsule, $\frac{1}{1}$; *ditto.*

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G.—SARSON, OR INDIAN COLZA.

BRASSICA CAMPESTRIS *Linn.*, var. SARSON *Prain.*

B. glauca *Willm.* ex *Hook.* in *Kew Report* for 1877, p. 34.
B. campestris *H. f. & T. Journ. Linn. Soc.*, v. 169, in part.
B. campestris SUBSP. Napus *H. f. & T.*, *Flor. Brit. Ind.*, i. 156, in part.
B. campestris SUBSP. Napus VAR. glauca *Duthie & Fuller, Field and Garden Crops*, ii. 28.
B. campestris SUBSP. Napus VAR. trilocularis *Duthie & Fuller, Field and Garden Crops*, ii. 28.
B. campestris SUBSP. Napus VAR. quadrivalvis *Duthie & Fuller, Field and Garden Crops*, ii. 29.
B. trilocularis, *H. f. & T. Journ. Linn. Soc.*, v. 170; *Flor. Brit. Ind.*, i. 156.
B. quadrivalvis, *H. f. and T. Journ. Linn. Soc.*, v. 169; *Flor. Brit. Ind.*, i. 156.
B. campestris SUBSP. campestris VAR. glauca *Watt, Dict.*, i. 524.
B. campestris VAR. glauca *Kew Bulletin* for 1894, p. 96.
Sinapis glauca *Roxb.*, *Hort. Beng.*, 48; *Flor. Ind.*, iii. 118.
S. trilocularis *Roxb.*, *Hort. Beng.*, 48; *Flor. Ind.*, iii. 121.

A cold-weather crop of tall annual herbs 4-5 feet high, rather rigid and unbranched or branching to form a narrowly pyramidal head 1-1·5 feet across. *Root* thickish, tapering, 6-8 in. long. *Leaves* large, the lower lyrate-pinnatipartite 6-8 in. long, 2-3 in. wide, decreasing upwards, those in upper
or sub
auricle
some
5th leaf, usually only higher up, branches subfastigiate usually shorter than main stem, or stem often unbranched. *Flowers* in oblong corymbs, about 2 in. long when lowest flower opens, subsequently elongating into a raceme 8—16 in. long with subequal *ascending* slender pedicels ·75 in.

long, without bracts or bractlets, slightly elongating in fruit, at which time they may be thickened and suberect, or remain slender and become decurved. *Sepals* suberect; inner pair ·25 in. long, exceeding the outer pair ·2 in. long—all ·15 in. wide, glaucous, becoming yellow before falling. *Corolla* ·4 in. across; petals with yellow claw ·15 in. long, and bright yellow, obovate ascending blade ·3 in. long, ·2 in. across. *Pods* various; normally ·4 in. wide, broader than thick, 2-valved and 2-chambered; in abnormal forms as thick as wide, by lateral expansion of one or both seed-bearing ribs (placentæ) spuriously 3–4-valved, and then by absorption, lateral displacement, or doubling of the partition variously 1-, 2-, or 3-chambered; in erect-fruited forms *pods*, including beak, 2 in. long if 3–4-valved, to 2·5 in. if 2-valved; in pendent-fruited forms 3–3·25 in. long; beak conical, stout, often 1 in. long; valves thickly leathery, with a weak midrib and indistinct looping nerves on each half-valve. *Seeds* varying from 30–80 in a pod, subspherical, dingy white, yellow or brown, almost smooth, cotyledons pale yellow.

There are three different characters by which it has been proposed to break up the *Sarson* crop into races, varieties, even species. These are—

(1) The colour of the seeds.
(2) The number of valves and chambers in the pod.
(3) The direction of the stalks when the fruits are ripe.

They are w [illegible]

COLOUR OF [illegible]
only white-s[illegible] also the case in Chota Nagpur. In most of our South Bihar and Tirhut samples a certain number of brown *Sarson* seeds are always found, but even in these samples the proportion of white seed greatly exceeds the proportion of [illegible]

sample [illegible]
and it [illegible]
where i[illegible]
charact[illegible]
importance in subdividing *Sarson*. But we have ample proof that the character is of very little real value, for [illegible] samples of a *Sarson* from [illegible] as *Sarson Zard*, in which [illegible] on the same specimen!

Number of valves and chambers.—The number of valves, although the character has been used by Hooker and Thomson to separate one form of *Sarson* as a species (*B. quadrivalvis*), possesses no greater value than the character of colour of seed. Among the 45 plots of *Sarson* cultivated by the writer, 19 were what may be termed *Asl-Sarson* or *Sarson* with pods of the normal *Brassica* type, almost erect, 2-chambered from the presence of a complete partition extending from placenta to placenta, and with only 2-valves, the width of the valves rather exceeding the thickness of the pod. On the other hand, six plots contained plants that had pods very regularly 4-valved, with the partition quite absent (Plate VII, figs. 2, 7); occasionally pods were found that had a partition present but only towards one side (Plate VII, fig. [illegible] ad but three [illegible] (placentæ) remaining normal; a few pods were also found in these plots with three chambers owing to the partition being doubled (Plate VII, fig. 4). These six plots were the only ones that could be looked on as examples of clean *Brassica quadrivalvis* H. f. and T.

There were four other plots of what at first sight appeared to be unmixed *B. quadrivalvis*, where closer examination showed that while all the fruits at the base and throughout the lower two-thirds of the racemes were 4-valved, and had no partition, those towards the *top of the racemes* were all 2-valved and 2-chambered, as in normal *Sarson*. Among the plants of this plot, 4-valved and 3-valved pods with laterally displaced partitions (Plate VII, figs. 3, 4) were far more common than among those of the six plots mentioned in the preceding paragraph. And in one very interesting plot, raised from seed received from Arrah as *Jauda Sarson*, the pods seen from outside looked exactly like those of *Brassica 4-valvis*, since they were as broad as thick, and had the seed-bearing ribs expanded till they were almost as wide as the valves. On being opened, however,—and once the discovery was made, many hundreds of pods from several scores of plants were opened—the pods were in every case found to possess a complete and centrally situated partition with the normal number of rows of seeds (Plate VII, fig. 6).

Which of the two conditions—that where all the pods are to outward appearance 4-valved, and yet in reality are only 2-valved, or that in which one finds every sort of transition between 2-valved and 4-valved pods—is to be deemed the midway stage in the transition from normal 2-valved to

specialized 4-valved *Sarson*, and which may be looked on as a reversion from the unnatural 4-valved to the normal 2-valved state must remain an open question. Between them, however, they seem to the writer to prove quite satisfactorily that *B. 4-valvis* has no claim to be considered a separate variety, far less a distinct species.

That the 4-valved state is an abnormal deviation from the type goes almost without saying. Its abnormal nature is, however, corroborated by a tendency that exists to further abnormality. Among the large number of pods examined it was found that, *of the pods lowest down in the raceme*, about 1 per cent. in those plots where all the pods were 4-valved, and about 2 5 per cent. in the plots where the pods were 4-valved below and 2-valved above, afforded examples of the abnormal replacement of one or more seeds by small deformed pods enclosed within the main one (PLATE VII, fig. 8) ; and among the many hundreds of pods opened by

rarer ab-
main pod
was found
rmal partitions and the usual number of rows of seeds, the writer is inclined to think that these last may illustrate a partial reversion from the 4-valved to the normal type, the other conditions being perhaps instances of the evolution of the 4-valved state.

In six other plots the plants were found to consist of about equal parts of 2-valved and 4-valved erect-fruited *Sarson*. In four of these six plots all the 4-valved plants were true to their type ; in the other two the instances of transition from the 4-valved to the 2-valved state were marked and abundant.

The question why, supposing we are right in considering the 4-valved state an abnormal one, our Indian farmers should have in an empirical manner, as the cleanness of many of the samples show, in certain districts consciously or unconsciously selected a 4-valved kind of *Sarson*, while no corresponding kind of *Tori* has been produced, does not seem difficult to answer. The object in the case of any crop grown purely for the sake of its seeds must obviously be to get as much seed as possible. This object, as we shall presently see, has in the case of *Tori* been attained by selecting a plant that branches rer
case of *Sarson*, on the otl
selecting kinds with pods
seeds is multiplied. To

NUMBER OF VALVES AND CHAMBERS.—The number of valves, although the character has been used by Hooker and Thomson to separate one form of *Sarson* as a species (*B. quadrivalvis*), possesses no greater value than the character of colour of seed. Among the 45 plots of *Sarson* cultivated by the writer, 19 were what may be termed *Asl-Sarson* or *Sarson* with pods of the normal *Brassica* type, almost erect, 2-chambered from the presence of a complete partition extending from placenta to placenta, and with only 2-valves, the width of the valves rather exceeding the thickness of the pod. On the other hand, six plots contained plants that had pods very regularly 4-valved, with the partition quite absent (PLATE VII, figs. 2, 7); occasionally pods were found that had a partition present but only towards one side (PLATE VII, fig. [illegible] ad but three [illegible] (placentæ) remaining normal; a few pods were also found in these plots with three chambers owing to the partition being doubled (PLATE VII, fig. 4). These six plots were the only ones that could be looked on as examples of clean *Brassica quadrivalvis* H. f. and T.

There were four other plots of what at first sight appeared to be unmixed *B. quadrivalvis*, where closer examination showed that while all the fruits at the base and throughout the lower two-thirds of the racemes were 4-valved, and had no partition, those towards the top of the racemes were all 2-valved and 2-chambered, as in normal *Sarson*. Among the plants of this plot, 4-valved and 3-valved pods with laterally displaced partitions (PLATE VII, figs. 3, 4) were far more common than among those of the six plots mentioned in the preceding paragraph. And in one very interesting plot, raised from seed received from Arrah as *Jauda Sarson*, the pods seen from outside looked exactly like those of *Brassica 4-valvis*, since they were as broad as thick, and had the seed-bearing ribs expanded till they were almost as wide as the valves. On being opened, however,—and once the discovery was made, many hundreds of pods from several scores of plants were opened—the pods were in every case found to possess a complete and centrally situated partition with the normal number of rows of seeds (PLATE VII, fig. 6).

Which of the two conditions—that where all the pods are to outward appearance 4-valved, and yet in reality are only 2-valved, or that in which one finds every sort of transition between 2-valved and 4-valved pods—is to be deemed the midway stage in the transition from normal 2-valved to

specialized 4-valved *Sarson*, and which may be looked on as a reversion from the unnatural 4-valved to the normal 2-valved state must remain an open question. Between them, however, they seem to the writer to prove quite satisfactorily that *B. 4-valvis* has no claim to be considered a separate variety, far less a distinct species.

That the 4-valved state is an abnormal deviation from the type goes almost without saying. Its abnormal nature is, however, corroborated by a tendency that exists to further abnormality. Among the large number of pods examined it was found that, *of the pods lowest down in the raceme*, about 1 per cent. in those plots where all the pods were 4-valved, and about 2·5 per cent. in the plots where the pods were 4-valved below and 2-valved above, afforded examples of the abnormal replacement of one or more seeds by small deformed pods enclosed within the main one (Plate VII, fig. 8); and among the many hundreds of pods opened by the writer, one was found that exhibited the much rarer abnormality of an axial accessory pod inside the main pod (Plate VII, fig. 9); as no such abnormality was found in any of the outwardly 4-valved pods with normal partitions and the usual number of rows of seeds, the writer is inclined to think that these last may illustrate a partial reversion from the 4-valved to the normal type, the other conditions being perhaps instances of the evolution of the 4-valved state.

In six other plots the plants were found to consist of about equal parts of 2-valved and 4-valved erect-fruited *Sarson*. In four of these six plots all the 4-valved plants were true to their type; in the other two the instances of transition from the 4-valved to the 2-valved state were marked and abundant.

The question why, supposing we are right in considering the 4-valved state an abnormal one, our Indian farmers should have in an empirical manner, as the cleanness of many of the samples show, in certain districts consciously or unconsciously selected a 4-valved kind of *Sarson*, while no corresponding kind of *Tori* has been produced, does not seem difficult to answer. The object in the case of any crop grown purely for the sake of its seeds must obviously be to get as much seed as possible. This object, as we shall presently see, has in the case of *Tori* been attained by selecting a plant that branches remarkably freely and widely. In the case of *Sarson*, on the other hand, it has been attained by selecting kinds with pods in which the number of rows of seeds is multiplied. To what extent the custom that almost

NUMBER OF VALVES AND CHAMBERS.—The number of valves, although the character has been used by Hooker and Thomson to separate one form of *Sarson* as a species (*B. quadrivalvis*), possesses no greater value than the character of colour of seed. Among the 45 plots of *Sarsoñ* cultivated by the writer, 19 were what may be termed *Asl-Sarson* or *Sarson* with pods of the normal *Brassica* type, almost erect, 2-chambered from the presence of a complete partition extending from placenta to placenta, and with only 2-valves, the width of the valves rather exceeding the thickness of the pod. On the other hand, six plots contained plants that had pods very regularly 4-valved, with the partition quite absent (PLATE VII, figs. 2, 7); occasionally pods were found that had a partition present, but only towards one side (PLATE VII, fig. 3), and a considerable percentage of such pods had but three valves owing to one of the two seed-bearing ribs (placentæ) remaining normal; a few pods were also found in these plots with three chambers owing to the partition being doubled (PLATE VII, fig. 4). These six plots were the only ones that could be looked on as examples of clean *Brassica quadrivalvis* H. f. and T.

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specialized 4-valved *Sarson*, and which may be looked on as a reversion from the unnatural 4-valved to the normal 2-valved state must remain an open question. Between them, however, they seem to the writer to prove quite satisfactorily that *B. 4-valvis* has no claim to be considered a separate variety, far less a distinct species.

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. . . .

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universally prevails of growing *Sarson* along with other crops and of growing *Tori* as a crop by itself is the cause or the effect of the change or of the selection, must be left to others to decide.

The number of partitions, and therefore of chambers, in the pod has been used, at least nominally, in distinguishing still another species—*B. trilocularis*, first separated by Roxburgh and afterwards accepted by Hooker and Thomson. The condition indicated by the name implies the presence of two partitions, and therefore of three chambers (PLATE VII, fig. 11). It is not, however, the rule even in the form to which it gives its name; more often, just as in *B. 4-valvis*, we find in *B. trilocularis* only one partition, towards one side; oftener still we find no partition whatever. But though this is the condition which has given *B. trilocularis* its *name*, the differentiation of the form known as *B. trilocularis* depends in reality on the character next to be considered.

DIRECTION OF THE PODS WHEN RIPE.—The direction of the pods, whether erect or pendent, has been used by Roxburgh, and after him by Hooker and Thomson, as the basis for the separation of another species; *Sinapis trilocularis* Roxb. (*Brassica trilocularis* H. f. and T.) only differs from *Sarson* in having pendulous pods.

Only five unmixed samples of true *B. trilocularis*, with the pods all down-turned and all 4-valved, were sent for sowing. Other two samples were received, in which *B. 3-locularis* and *B. 4-valvis* were present in about equal quantity without an appreciable number of deviations from either kind. But it was clearly proved that *B. trilocularis* has no more claim to separate specific, or even varietal rank than *B. 4-valvis* has; for there was one plot, the seeds of which were sent from the Sonthal Parganas as *Porbi Sarisha*, in which all the plants had pendent pods, but in which many of the plants had the pods towards the tops of the racemes only 2-valved; while in two other plots all the pods were down turned, exactly as in *B. 3-locularis*, but all the pods on every plant were only 2-valved. The parallel between the erect and the pendent-fruited *Sarsons* as regards the structure of their pods is, therefore, complete.

Finally, perhaps the most interesting sample of *Sarson* received was one of which the seed was sent from Nilphamari in Rangpur. Many of the plants that came up in this plot showed all the transitions possible between erect, spreading, and pendent pods. It is true that in their early stages the pods even of genuine *B. trilocularis* are erect, and only become pendent as they ripen. In the plants referred to

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however, the pods toward the top of the stem remained erect when ripe, and in this state, moreover, resembled those of *B. 4-valvis* in being decidedly shorter than the lower pods, which were those of typical *B. 3-locularis*.

Not only then are neither *B. 4-valvis* nor *B. 3-locularis* specifically separable from *Sarson* proper, the differences between the two are, at most, not more than racial. Using this last character we therefore find that there are two races of *Sarson*—

(1) *Natua*, erect-fruited, and
(2) *Ulti*, nodding-fruited,

both races passing insensibly from a 2-valved to a 4-valved form.

No *Sarson* of any kind was sent from Chittagong. Its place there is taken by a quite different plant that does not seem distinguishable from true *Colza*.

1. (*a*) Erect-fruited, 2-valved *Sarson* is common in South Bihar, Chota Nagpur, Orissa, West and East Bengal. But it does not extend north of the Ganges, for not a single sample has been received from Tirhut or from North Bengal.

(*b*) Erect-fruited, 4-valved *Sarson* is, on the other hand, very common in Tirhut and North Bengal; but it extends south of the Ganges, for it is common in South Bihar, and is also found in the Mymensingh district of East Bengal. It seems, however, to be quite unknown in Chota Nagpur, Orissa, or West Bengal, and is not sent from any part of [illegible]

[illegible] *Sarson* is almost strictly [illegible]

(*b*) Nodding-fruited, 4-valved *Sarson* occurs also in North Bengal, and is mainly confined to that region. But it is also reported from South Bihar (Arrah) and from the neighbouring district of Palamau in Chota Nagpur, while from the Sonthal Parganas in West Bengal is reported, under the name *Purbi* (Eastern) *Sarisha*, a transition from the 4-valved to the 2-valved state, or *vice versâ*, of nodding-fruited *Sarson*.

That the *Sarsons* above described constitute in the botanical sense only different forms of the same plant will be sufficiently apparent from what has been said above, even to those who are not familiar with the *Sarson* crop in all its stages.

The precise treatment to be accorded to them is not, however, at first so clear. Roxburgh treated erect-fruited 2-valved *Sarson* as one species (*Sinapis glauca*) and nodding-

DETAILS OF SAMPLES OF *SARSON*.

Cultivated at Sibpur Experimental Farm, 1896-97.

	Erect-fruited.		Nodding fruited.	
	2-valved.	4 valved.	2-valved.	4-valved.
Tirhut.		Saran .. *Sarson!*		
		Champaran ... *Sarson!*		
		Darbhanga . *Sarson!*		
S. Bihar.	Shahabad (Bhojpur) :— Seed, large yellow .. *Piarka Tora!*; " medium yellow *Piarki Tori!*; " large brown .. *Lalka Tora!*; Pods, broad! ... *Jowda Sarson!*	Shahabad (Arrah) .. *Natua Sarson!*		Shahabad (Arrah) *Ulti Sarson!*
		Patna ... *Sarson!*		
		Gaya (Manghlawan) .. *Sarson!*		
		" (Pariya) ... *Tora!*		
	Monghyr .. *Sarson!*			
Chota Nagpur.	Hazaribagh [Rai] ... *Sarson!*			Palamau ... *Sarson!*
	Lohardaga ... *Sarson!*			
	Manbhum ... (No name)!			
	[Singhbhum (mixed with *Rái* and sent under that name)!]			
Orissa	Angul ... *Ganga Toria Saruha!*			

grown at Sibpur.

W. Bengal.	Sonthal Parganas (Birajpur) ... *Thari !*		Sonthal Parganas . *Dudhia or Purbi Sarisha !* (a transition form from	Sonthal Parganas ... *Dudhia or Purbi Sarisha !* 2-valved to 4-valved pendent).
	" " (Godda) *Sarisha !*	Bankura ... *Rái or Jhanti Sarish !*		
		" .. *Seti or Piyala Sarisha !*		
	Birbhum ... *Sheti Sarisha !*	Midnapore . . *Sadha Bheta Rai !*		
	Midnapore . . *Sheti Rái !*	Burdwan .. *Sheti Rái !*		
	Burdwan *Sheti Rái !*			
	Jessore *Sheti Sarisha !*			
	Murshidabad .. *Sheti !*			
N. Bengal.		Dinajpur .. *Taro Sarisha !*		
		Rajshahi *Seti Sarisha !*	Purnea ... *Tara !*	Purnea . . *Sarsoo !*
			Jalpaiguri ... *Swet Sarisha !*	
		Rangpur *Dhepa Sarisha !*		Rangpur ... *Sheo Sarisha !*
				Kurseong ... *Sarsoo !*
E. Bengal.		Mymensingh (Jamalpur) *Dhupi Sarisha !*		
		" (Netrakona) . *Sweti Sarisha !*		
	Dacca ... *Swet Sarisha !*			
	Backergunge ... *Makhan Dhana Sarisha !*			
	Noakhali ... *Dhone Sarisha !*			
	Tippera . *Dhone Sarisha !*			

The Hazaribagh " *Rái* " was a mixture of *Sarson* and *Tori*.

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EXPLANATION OF PLATES V, VI, AND VII.

PLATE V.

BRASSICA CAMPESTRIS Linn. *var.* SARSON Prain.

(Sinapis glauca *Roxb.*)

Race with erect, 2-valved pods.

1. Plant before flowering, about $\frac{1}{3}$; *from an example grown at the Sibpur Experimental Farm, raised from seed sent from Jessore as Sheti Sarisha.*
2. Portion of main stem with leaf and branch, $\frac{1}{2}$; *reduced from Roxburgh's original drawing.*
3. Flowering branch, passing into fruit, $\frac{1}{4}$; *from Roxburgh's drawing.*

PLATE VI.

BRASSICA CAMPESTRIS Linn. *var.* SARSON Prain.

(Sinapis trilocularis *Roxb.*)

Race with pendent, 4-valved pods.

1. Portion of stem, $\frac{1}{2}$; *reduced from Roxburgh's original drawing.*
2. Flowering branch, $\frac{1}{4}$; *from Roxburgh's original drawing.*
3. Ripe capsule, $\frac{1}{4}$; *from Roxburgh's drawing.*
4. The same, cut transversely to show valves and dissepiments, $\frac{3}{4}$; *from Roxburgh's drawing.*

PLATE VII.

BRASSICA CAMPESTRIS Linn. *var.* SARSON Prain.

Capsules of the different races, from examples cultivated at the Sibpur Experimental Farm.

1. Capsule of erect 2-valved; race "Natua," sub-race *glauca*, from Jessore.
2. Capsule of erect 4-valved; race "Natua," sub-race *quadrivalvis*, from Shahabad (Arrah)
3. Capsule of "Natua" Sarson, with only three valves and with the dissepiment to one side, from Burdwan.
4. Capsule of "Natua" Sarson, with four valves and two dissepiments, from Burdwan.
5. Capsule of "Natua" Sarson, with four valves and no dissepiment, from Shahabad (Arrah).
6. Capsule of "Natua" Sarson, with apparently four, but really only two valves, sent as "Jauda" Sarson from Shahabad (Bhujpur).
7. Capsule of "Natua" Sarson, fully ripe, with seeds shed and valves fallen, from Shahabad (Arrah).
8. Capsule of "Natua" Sarson, with two seeds replaced by small abnormal capsules, from Darbhanga.
9. Capsule of "Natua" Sarson, with the axis ending in a small, complete, centrally-situated capsule within the normal capsule, from Burdwan.
10. Capsule of pendent 2-valved; race "Ulti," sub-race *simplex*, from Jalpaiguri.
11. Capsule of pendent 4-valved; race "Ulti," sub-race *trilocularis*, from Palamau.
12. Capsule of "Ulti" Sarson, with only three valves and with the dissepiment to one side, from Rangpur.
13. Capsule of "Ulti" Sarson, fully ripe, with seeds shed an valves fallen, from Purnea

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H.—TORI, LUTNI OR MAGHI; INDIAN RAPE.

BRASSICA NAPUS *Linn. Sp. Pl.*, 666; var. DICHOTOMA.

B. praecox *Waldst. & Kit. DC. Syst. Veg.*, ii. 593; *Prodr.*, i. 214.
B. campestris *H. f. & T. Journ. Linn. Soc.*, v. 169, *in part.*
B campestris SUBSP. Napus *H. f. & T. Flor. Brit. Ind.*, i. 156, *in part.*
B. campestris SUBSP. Napus VAR. dichotoma *Duthie & Fuller, Field and Garden Crops*, ii. 29.
B. campestris SUBSP. Napus VAR. Toria *Duthie & Fuller, Field and Garden Crops*, ii. 29; *Watt, Dict.*, i. 525.
B. glauca *Royle* ex *Atkins* in *Gaz. N.-W. Prov.*, x. 770, *not* Sinapis glauca *Roxb.*
B. campestris SUBSP. campestris VAR. dichotoma *Watt, Dict.*, i. 523, *excluding the synonyms* B. quadrilocularis *and* Sinapis trilocularis.
Sinapis dichotoma *Roxb. Hort. Beng.*, 48; *Flor. Ind.* iii. 117.

A cold-weather crop in the Indian plains and spring crop of the Himalayan range of rather short annual, much-branching herbs 1—4 feet high; the branches slender, spreading and forming a loose lax head 2—3 feet across. *Root* slender, tapering, 4 in long. *Leaves* small, those at the base not exceeding 4 in. long by 2 in. wide, lyrate; all except the basal 2—3 auriculate decreasing upwards; those in the upper [illegible] gular- [illegible] with [illegible] auces-cent, glabrous except for a few hairs on the nerves of the lower leaves beneath. *Stem* branching from the axils of 4th to the 7th leaf upwards, all branches about as long and strong as main stem and again laxly branching. *Flowers* in short corymbs, about 1·5 in. long when the lowest flower opens, subsequently elongating into a raceme 8 in. long with equal pedicels ·6—·7 in. long, not appreciably lengthening in fruit, slender and without bracts or bractlets. *Sepals* spreading ·2 in. long, ·08 in. wide, green, becoming yellowish before falling. *Corolla* ·6 in. across; petals with a pale-green narrow claw ·12 in. long and a bright yellow regularly obovate blade ·25 in. long, ·2 in. across, veins faintly greenish beneath. *Pod* ascending 2-valved, including

the beak, 2—2·25 in. long; beak narrowly conical, ·6 in. long; valves very convex, flexible, thinly leathery, with a strongish midrib, and with slender not prominent looped veins on each half-valve; valves at first much beaded opposite the seeds, less so when fully ripe. *Seeds* about 10 under each valve, bright brown, finely rugose with a greenish hilum; cotyledons yellow.

There is no possibility of confusing this plant either with *Sarson*, from which it differs very markedly in flowers, pods and seeds, as well as in habit and general facies, or with *Rái*, from which it differs in having stem-clasping leaves.

There are two forms of this mustard, very readily separated in extreme examples by the size of the plant and the rates at which they come to maturity; though, as will readily be believed, when two such indefinite characters have to be relied upon,—for there is absolutely no difference between the forms in leaf or flower, pod or seed—they are not always easily distinguished, because they pass into each other in both respects.

These forms may be defined thus:—

(1) Tall, later *Tori*; 2—4 feet high; ripening, near Calcutta, in the last week of January.

(2) Dwarf, earlier *Tori*; 1—1·5 feet high, ripening a week to ten days before the other.

The taller later kind is the plant which is termed *Brassica campestris* SUBSP. *Napus* VAR. *dichotoma*, by Duthie and Fuller. The dwarf earlier sort is the VAR. *Toria* of these authors and of Watt; it is also, so these writers say, the *Sinapis glauca* of Royle as opposed to *Sinapis glauca* of Roxburgh. Roxburgh's *Sinapis dichotoma* is not, however, precisely the equivalent of Duthie and Fuller's VAR. *dichotoma*, for Roxburgh's species includes both forms.

Our Indian "Rape," for Tori is most certainly the representative in India of the European Rapes, just as *Sarson* is representative of the European Colzas, differs from the ordinary European plant mainly in having ascending pods. It agrees very well with specimens sent to Calcutta from various European herbaria as representative of the summer-rape of Europe—*Brassica praecox*, of which, as the *Dictionary of Economic Products* appears to suggest, it is probably only a form. At the same time *B. praecox* hardly seems to the writer more than a race, though no doubt a very distinct one, of *B. Napus* VAR. *oleifera*. For convenience' sake it is here treated as a variety, and the term *dichotoma*, being older than the term *praecox*, is adopted in that sense.

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DETAILS OF SAMPLES OF *TORI.*

Cultivated at Sibpur Experimental Farm, 1896-97.

	TALLER, LATER.		SHORTER, EARLIER.	
TIRHUT.	Champaran	(no name) !		
	Muzaffarpur	.. *Tori !*		
	Darbhanga	.. *Tori !*		
			North Bhagalpur	... *Tori !*
S. BIHAR.	Monghyr	... *Rdichi !*		
			Gaya	... *Tori !*
CHOTA NAGPUR.	Lohardaga	... *Lutni !*		
	Palamau	.. *Lutni !*		
			Hazaribagh	... [*Rai !*] *Lutni !*
			Manbhum	... ("Mustard") !
	Singhbhum	... *Lutni !*	Singhbhum	... *Chota Sarisha !*
ORISSA.	Puri	... *Sarisha !*		
	Cuttack	... *Kala Sarisha !*		
	Angul	... *Bor Sarisha !*		
			Balasore	... ("Mustard") !

grown at Sibpur.

W. BENGAL.	Sonthal Parganas	... *Lutni*	Sonthal Parganas	... *Maghi!*
			Birbhum	... *Maghi* or *Lutni Sarisha!*
			Burdwan	. *Sanchi!*
	Hooghly	... *Bhunri!*	Midnapore	. *Sadharan Sarisha!*
			24-Parganas	... ("Mustard")!
	Nadia	.. *Sarisha!*		
	Murshidabad	... *Sarisha! Jema Sarisha!*	Murshidabad	... *Bhati Sarisha!*
N. BENGAL.	Siliguri	... *Kazla!*	Purnea	... *Tori!*
	Jalpaiguri	.. *Sheoa Sarisha!*	Siliguri	*Turi!*
	Rangpur (Nilphamari)	.. *Maghi Sarisha!*	Jalpaiguri	... *Maghi Sarisha!*
	" (Kurigram)	... *Kazla!*		
	Dinajpur	... *Sarisha!*	Dinajpur	. *Turi!*
	Malda	... *Sarisha!*		
			Rajshahi	.. *Sarisha!*
			Pabna	... *Sarisha!*
E. BENGAL.			Mymensingh	*Maghi Sarisha!*
			Dacca	*Maghi Sarisha!*
			Faridpur	... *Maghi Sarisha!*
			Backergunge	... *Maghi Sarisha!*
CHITTAGONG.			[Sadar	. ("Mustard")]!
			Raojan Tahsil	.. *Sarisha!*
			Cox's Bazar	. "Reddish Rape"

The Hazaribagh sample named *Rái* was a mixture of *Tori* and *Sarson* and contained no *Rai*.
The Chittagong "mustard" was a mixture of *Tori* and a plant identified with "European Rape."

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The detailed distribution of the two forms of *Tori* cultivated in Bengal, as shown by samples sent to Sibpur, is given in the foregoing table, along with the names that accompanied each sample. The general distribution is indicated in MAP I, SECTION B.

The taller later *Tori* is quite unknown in EAST BENGAL or in CHITTAGONG. It is very common in the other Divisions The shorter earlier *Tori* is sent from every Division, and is the most universally grown mustard of the Lower Provinces.

In Northern Bengal, Dr. Buchanan-Hamilton informs us, this plant is sometimes deliberately sown very thickly; it then comes up leafy and weak, and the leaves are used as a potherb. The same practice prevails in Sikkim; when grown for its leaves, it is spoken of as a small kind of *Pasái*, the name for *Brassica rugosa*; when sown for the sake of its seeds only, it is termed *Toori*, the form of the name *Tori* that prevails in North Bengal.

EXPLANATION OF PLATE VIII.

BRASSICA NAPUS Linn. *var.* DICHOTOMA Prain.

(Sinapis dichotoma *Roxb.*)

1. Plant before flowering, about $\frac{1}{8}$; *from an example cultivated at the Sibpur Experimental Farm, raised from seed received from Hooghly.*
2. Portion of stem and primary branches with leaves, $\frac{1}{2}$; *reduced from Roxburgh's original drawing.*
3. Branch with flowers and fruits, $\frac{1}{1}$; *from Roxburgh's original drawing.*

K.—BHUTIA MOOLA, OR BHUTIA RAI.

BRASSICA NAPUS *Linn. Sp. Pl.* 666; var. ESCULENTA *DC., Prodr.*, i. 214.

Napus dulcis *Blackw., Herb.*, t. 410.

A cold-weather crop, in the Eastern Himalaya, of short annual, much-branching herbs, 1·5–3·5 feet high, the branches slender, and forming a rather lax head 1·5–2 feet

across, root swollen, succulent, 2·5 in. long, 2 in. in diam *Leaves* small, those at the base not exceeding 4 in. long by 2 in. wide, lyrate, all except the basal 2—3 auriculate, decreasing upwards, those in the upper third of the stem 1—2 in. long, ·5—·75 in. across, triangular-lanceolate to a bluntish tip, with an entire margin and with large stem-clasping auricles at the base, pale-green, glaucescent, glabrous. *Stems* branching from the axils of the 4th to the 6th leaf upwards, the branches about as strong as, and not much shorter than, the main stem, and again branching *Flowers* in short corymbs about 1·5 in. long when the lowest flower opens, subsequently elongating into a raceme [illegible]

[illegible]

yellowish before falling. *Corolla* [illegible] in. across, petals with a pale-green, narrow claw ·12 in. long and a bright yellow regularly obovate blade ·25 in. long, ·2 in. across, veins faintly greenish beneath. *Pod* 2-valved, including the beak 2—2·25 in. long, beak narrowly conical, ·6 in. long; valves very convex, flexible, thin, leathery, with a strongish midrib and with slender looped veins on each half-valve; valves not beaded [illegible] it 10 under each valve, finely [illegible] cotyledons yellow. [illegible] 2,000—5,000 feet elevation, both on account of its leaves and for its esculent root, not for its seeds.

Though sometimes spoken of as a *Moola* and at other times as a *Rai*, it is neither the one nor the other. The reason for its being termed now a 'radish' and now a 'mustard' is that the people wish to be emphatic in negativing the suggestion that it is a turnip. This they certainly are right in insisting upon; their plant is a rape, and the old figure of sweet rape in Mrs. Blackwell's *Herbal* well represents it.

The Bhutias do grow a turnip, and that too of a flavour and quality which no European kind approaches when grown in Sikkim. It is quite unlike the sweet rape in the fact that it never flowers in Sikkim, and the Bhutias have to import fresh seed every year from Tibet. Whether this Bhutia turnip be a true turnip or a Rutabaga, the writer is as yet unable to say, and it will not be possible to obtain complete information till another cold season.

EXPLANATION OF PLATE IX.

BRASSICA NAPUS Linn. *var.* ESCULENTA DC.

1. Root, ½; *from a specimen cultivated at Rungbee, Darjeeling district.*
2. Portion of stem with leaves, ½; *ditto.*
3. Flowering branch, ½; *ditto.*
4. Fruiting branch, ½; *ditto.*

I.—CHINA CABBAGE; CHINA GOBI OR PAK-CHOI.

BRASSICA CHINENSIS *Linn. Cent.*, 19, n. 52; *Amoen. Acad.*, iv. 281; *DC. Prodr.*, i. 215; *Franch. Mem. Sc. Nat. Cherb.*, xxiv. 200.

B. chinensis *Linn.* VAR.—*Vilmorin, Les Plantes potagères*, 397.

B. campestris *Forbes & Hemsl. Journ. Linn. Soc.*, xxiii. 46 *in part, not of Linn.*

B. juncea *Forbes & Hemsl. Journ. Linn. Soc.*, xxiii. 47 *in part, not of H. f. & T.*

B. oleracea *Linn. Sp. Pl.* 667, VAR. chinensis *Prain.*

Sinapis brassicata *Linn., Syst.* ed. xii. iii. App. 231; *Roxb. Hort. Beng.*, 48; *Flor. Ind.*, iii. 120.

Pak-choi *Vilmorin, l.c.*; Pak-tsoi *Roxb., Flor. Ind.*; Yea-tsoi *Roxb., Hort. Beng.*

tapering, 6 in. long. *Leaves* very large, the blades of the basal 8—12 in. long, 5—8 in. wide, obovate or oval-obtuse, the margin entire, more or less undulate, tapering abruptly at the base, where they are slightly lobed or lyrate, to a thick, white fleshy stalk 8—12 in. long, 1—1·5 in. wide, continued into the leaf-blade as a broad white fleshy main-nerve, neither ridged nor bristly, giving off fanwise several smaller white basal veins, the main rib also branching laterally

in dense wide corymbs 1 in. long and 2 in. across when the flowers open, subsequently elongating into racemes 6—8 in. long, with equal pedicels ·7—·8 in. long, slender and without bracts or bractlets, elongating slightly in fruit. *Sepals* slightly spreading, ·2 in. long, ·08 in. wide, still glaucous and greenish when they fall. *Corolla* ·6 in. across; petals with a yellow claw ·15 in. long and a spreading bright yellow orbicular blade ·25 in. across, veins darker orange above. *Stamens*, the short pair with recurved anther-tips, the two longer pairs with anther-tips incurved. *Pods* 2-valved, including beak 2—2·5 in. long, ·25 in. thick; beak rather thickly conical, ·5 in. long; valves convex, rigidly leathery, rather finely nerved, distinctly beaded opposite the seeds. *Seeds* 10—15 under each valve, spherical, dark-brown, somewhat rugose; hilum pale red-brown; cotyledons pale yellow.

This is certainly of Chinese origin. It does not appear to have ever been introduced by an overland route, and the first mention of its importation to India is that by Roxburgh in 1814. It never seems to have been a favourite vegetable, in spite of the fact that it is available in the rainy season when other vegetables are scarce, though in certain circles it is viewed with such favour that an order has recently been issued enjoining its cultivation in jail gardens. Prisoners are said to like it; it is, however, doubtful what value can be placed on a prisoner's opinion; any one save a prisoner, questioned regarding the merits of China cabbage, is likely to say he did not know of their existence.

Vilmorin terms this a "Cabbage," and the writer fully believes that we see in this plant yet another derivate of the stock from which Cabbage, Borecole, Broccoli, and Kohl-Rabi alike have sprung, as different in character from any of these as they are from each other. Forbes and Hemsley, however, think rather that it may be a derivate of [illegible] n

identifying this plant with the *Sinapis brassicata* of Linnaeus and of Willdenow. If this be so, then *Sinapis brassicata* Linn. and the plant that by common consent we identify with *Brassica chinensis* are one and the same thing. Forbes and Hemsley disagree with Roxburgh, and identify *S. brassicata* Linn., with *B. juncea* H. f. and T. This is not a possible identification, since Linnaeus says *S. brassicata* has the uppermost leaves stem-clasping, while the one character that makes the identification of *S. juncea* certain is that all its leaves taper to a narrow wedge-shaped base. That

S. brassicata Roxb. is the same as the *Brassica chinensis* of gardens admits of no dispute: not only is Roxburgh's description full and accurate; he has left behind an excellent coloured drawing, which shows that his plant not only bears the same Chinese name, but is actually the same as the plant figured 80 years later by Vilmorin.

EXPLANATION OF PLATE X.

Brassica chinensis *Linn.*

1. Plant before flowering, about $\frac{1}{12}$; *from Vilmorin.*
2. Radical leaf, $\frac{1}{3}$; *reduced from Roxburgh's original drawing.*
3. Portion of flowering-stem, branch and leaves, $\frac{1}{3}$; *reduced from Roxburgh's original drawing.*
4. Stem-leaf, detached, $\frac{1}{3}$; *reduced from Roxburgh's original drawing.*
5. Portion of flowering-stem, $\frac{1}{3}$; *reduced from Roxburgh's original drawing.*
6. Flower, $\frac{1}{1}$; *from Roxburgh's drawing.*
7. Capsule, $\frac{1}{1}$; *from Roxburgh's drawing.*
8. The same, cut transversely, $\frac{1}{1}$; *from Roxburgh's drawing.*

SECTION III.—SYSTEMATIC SYNOPSIS OF THE CABBAGES, COLZAS, RAPES AND RÁIS,

SHOWING THE RELATIVE POSITION OF THE BENGAL FORMS.

r green, stem at arrangement and coloration. The Cabbage group:—

Var. 1. *sylvestris.* Stem slender, branching; leaves glaucous; radical leaves vanishing, stem-leaves not collected in a head. Colewort or "Wild Cabbage" of Western Europe. More probably a plant that has become feral by reversion than the original stock whence cabbage has been evolved.

Var. 2. *acephala.* Stem stout, not swollen, simple or very rarely branched; leaves green; radical leaves vanishing, stem-leaves not collected in a head. Kale, Borecole, Cow-Cabbage are among the familiar forms included under this variety.

VAR. 3. *bullata.* Stem stout, not swollen, simple or very rarely branched; leaves glaucous, always bullate; radical leaves vanishing:—

Race a. SAVOY. Leaves in lax heads at top of stoutish stem, without leaf-buds.

Rac [illegible]

the present and of the fallen leaves.

VAR. 4. *Botrytis* Stem short, stout, not swollen, simple below stem-leaves; leaves glaucous, radical leaves vanishing; stem-leaves few, closely applied outside a rounded compact mass of white, fleshy branches. CAULIFLOWER and BROCCOLI.

VAR. 5. *capitata.* Stem short, stout, not swollen, simple; leaves glaucous; radical leaves vanishing; stem leaves many compacted in a dense head. CABBAGE proper, whether globose, flat or conical, and whether red or white

VAR. 6. *caulo-rapa.* Stem short, stout, simple, swollen turnip fashion beneath the origin of the loosely tufted glaucous stem-leaves; root-leaves vanishing. SIAM CABBAGE, or KOHL-RABI.

VAR. 7. *chinensis* (sp. *Linn.*). Stem none till time of flowering; leaves glaucous, radical leaves persisting to form a loose head like that of 'Leaf-Beet.' CHINA CABBAGE.

II.—BRASSICA CAMPESTRIS Linn. *ampl.* Leaves glaucous or green, usually at least the lowest leaves hairy; both stem- and flower-leaves clasping the stem at their bases. The RAPE and COLZA Group.

SUBSP. A. CAMPESTRIS (sp. *Linn.*). Leaves very glaucous, at least the lowest leaves with hairs beneath; radical leaves not stem-clasping. COLZA Group:—

VAR. 1. *agrestis.* Root fusiform, stem elongated, leaves mostly rather markedly hairy. WILD NAVEW of Western Europe. More probably a plant become feral by reversion than a wild native stock.

VAR. 2. *oleifera.* Root fusiform, stem elongated, only the lowest leaves markedly hairy, pods narrow, valves thin; plants naturally biennial. COLZA.

VAR. 3. *Sarson.* Root slender, tapering, stem elongated, only the lowest leaves markedly hairy, pods wide, valves thick; plants always annual. SARSON; the Indian COLZA.

Race α. NATUA. Pods erect—
Subrace 1. glauca (sp. *Roxb.*; *Wittm.*) Pods 2-valved.
Subrace 2. quadrivalvis (sp. *H. f. & T.*) Pods 4-valved.

Race β. ULTI. Pods pendent—
Subrace 1. simplex. Pods 2-valved. (This form has been overlooked by authors who have dealt with Indian Colza).
Subrace 2. trilocularis (sp. *Roxb.*; *H. f. & T.*) Pods 3-4-valved.

VAR. 4. *pabularia.* Root fusiform, stem abbreviated, root leaves subpersisting, edible

VAR. 5. [illegible] ip.

Subsp. B. NAPUS (sp. *Linn.*). Leaves only glaucescent, all or almost all glabrous, and all except the very lowest auricled at the base. The RAPE group—

VAR. 1. *oleifera.* Root very slender:—
Race α. Pods spreading. WINTER RAPE.
Race β. Pods ascending (sp. = B. præcox *Waldst. & Kit.*; Sinapis dichotoma *Roxb.*). SUMMER RAPE of Europe; the LUTNI, MÁGHI, or TORI of Bengal.

VAR. 2. *esculenta.* Root swollen. SWEET NAVET of Europe; BHUTIA MOOLA, or BHUTIA RAI of the Eastern Himalaya.

SUBSP. C. RAPA (sp. *Linn.*). Leaves green, the lower hairy or bristly, the upper smooth. The TURNIP group.

VAR. 1. *oleifera.* Root slender.
VAR. 2. *esculenta.* Root swollen. TRUE TURNIPS.
Subrace 1. oblonga. Roots oblong, gradually tapering downwards.
Subrace. 2. depressa. Roots globose, suddenly contracted into a slender tip.

Cabbages, Colzas, Rapes and Rais.

III.—Brassica juncea H. f. & T. Leaves green or little glaucous, usually the lowest hairy, none of them ever stem-clasping. The Rái group.

Subsp. A. juncea (sp. *Linn*). Leaves all lyrately-lobed except in the region of the inflorescence; radical leaves vanishing.

Var. 1. *agrestis* (sp.=Sinapis chinensis *Linn.*; S. patens *Roxb*). Stem-leaves little-lobed; plants small, wild. This appears rather to be a form of *Rái* become feral by reversion, than the stock whence *Rái* has originated

Var. 2. *oleifera* (sp.=Sinapis ramosa *Roxb.*). Stem-leaves much-lobed; plants tall, cultivated. The true Rái.

Subrace 1. elata. Tall, late, rough below, smooth above.

Subrace 2. aspera. Medium, early, rough with bristly hairs.

Subrace 3. laevis Medium, early, smooth, dark-stemmed.

Subsp. B. rugosa. None of the leaves distinctly lyrately-lobed, radical leaves persisting.

Var. 1. *agrestis* (sp.=B. dentata *Watt* Mss.). Leaf-margins very sharply dentate, midrib rather narrow, stem elongated. Perhaps this is a feral form of the next variety rather than a wild stock

Var. 2. *typica*. (sp.=Sinapis rugosa *Roxb.*). Leaf-margins very sharply dentate, midrib very broad, stem none till time of flowering; green stems not glaucous, leaves green. Pasái.

Var. 3. *cuneifolia* (sp. *Roxb.*). Leaf margins slightly serrate, midrib broad, stem none till time of flowering; purplish stems distinctly, leaves slightly glaucous. Lahi Sag.

SECTION IV.—GEOGRAPHICAL REVIEW OF THE LOWER PROVINCES MUSTARDS AS INDICATED BY SAMPLES CULTIVATED AT THE SIBPUR EXPERIMENTAL FARM, 1896-97.

Province.	Division	District.	Subdivision.	Mustard.	Names sent.	Remarks.
1	2	3	4	5	6	7
Bihar	Patna	Patna	Dinapore	RÁI	*Rái*	Tall, late subrace; sample clean.
"	"	"	"	SARSON	*Sarson*	Erect, 4 valved pods, seeds white; sample clean
"	"	Gaya	Ragai	RÁI	*Rái*, "Rape"	Smooth, early subrace; sample clean.
"	"	"	Manjhiawan	SARSON	*Sarson*, "Mustard"	Erect, 4 valved pods, seeds white; sample clean; reaped, 7th February 1897
"	"	"	Pariya Khurd	"	*Tora*, "Mustard"	Erect, 4-valved pods; seeds white; sample clean. This only differed from the preceding in ripening a week earlier, reaped, 1st February 1897.
"	"	"	Azmatganj	TORI	*Tori*, "Rape"	Short, early subrace; sample clean.
"	"	Shahabad	Arrah	RÁI	*Diarah Rai*	Smooth, early, sample clean
"	"	"	"	"	*Lutus Rai*	Smooth, early, sample clean, ripening several days before preceding.
"	"	"	"	SARSON	*Jauda sarso*, "Rape"	Erect, 2-valved, but with broad pods like those of 4-valved, seeds white; a little of pendent, 4-valved mixed.
"	"	"	"	"	*Natua sarso*, "Rape"	Erect, 4-valved; seeds white; sample clean
"	"	"	"	"	*Ulti sarso*, "Rape"	Pendent, 4-valved; seeds white; sample clean.
"	"	"	Bhojpur	RÁI	*Rái*, "Mustard"	Tall, late subrace, sample clean.
"	"	"	"	"	*Langri*, "Rape"	Tall, late and smooth, early subraces mixed
"	"	"	"	"	*Lalki tori*, "small reddish-brown Rape."	Tall late *Rái*; sample clean.
"	"	"	"	SARSON	*Piarka tora*, "bold yellow Rape."	A slightly branched, very late form; pods erect, 2 valved; seeds very large, yellow; sample clean.

"	"	"	"	"	*Piarki tori*, "yellow rape"	Erect, 2-valved; seeds white; sample clean. This is the common *Sarson* of Bengal Proper.
"	"	"	"	"	*Lalka'tora*, "bold reddish-brown Rape."	Erect, 2-valved; seeds brown; sample clean. Plants rather dwarf for *Sarson*; *early ripening. This is* the only unmixed brown-seeded *Sarson* received.
"	"	Muzaffarpur	Sitamarhi	RÁI	*Rái*	Tall, late subrace, sample clean.
"	"	"	"	SARSON	*Sarso*	Erect, 4-valved for the most part; some pendent, 4-valved scattered throughout the plot, but no intermediate forms; the pendent all white-seeded; a considerable proportion of the erect brown-seeded.
	"	"	"	TORI	*Tori*, "Rape"	Taller, later subrace, sample clean.
"	"	Darbhanga	*Madhubani*	RÁI	*Tori*	Rough, early subrace, sample clean.
"	"	"	"	SARSON	*Sarso*	Erect, 4-valved, seeds 85% white; 15% brown
"	"	"	"	TORI	*Ráchi*	Taller, later subrace, sample clean.
"	"	Saran	Chapra	RÁI	*Rái* or *lahi*	Tall, late subrace, sample clean.
"	"	"	"	SARSON	*Sarson*, "Rape"	Erect, 4-valved, but with the uppermost pods in most plants only 2-valved, seeds 90% white, 10% brown; interesting as a connecting form.
"	"	Champaran	Motihari	"	*Sarson*	Erect, 4-valved, seeds 85% white; 15% brown.
"	Bhagalpur	*Bhagalpur*	Supaul	RÁI	*Ráchi Rái*	Smooth, early subrace; sample clean.
"	"	"	"	SARSON	*Sarso*	Erect, 4-valved for the most part; some pendent, 4-valved scattered throughout the plot, but no intermediate forms, the pendent all white-seeded; a considerable proportion of the erect brown-seeded.
"	"	"	"	TORI	*Tori*	Shorter, earlier kind; sample clean.
"	"	Monghyr	Monghyr	RÁI	*Gota* or *tori*	Tall late subrace, sample clean.
"	"	"	"	SARSON	*Sarson*, "Rape"	Erect, 2 valved, 75% mixed with about 25% erect 4-valved; seeds 95% white, 5% brown.
"	"	"	"	TORI	*Ráchi*	Taller, later kind; sample clean.
"	"	Purnea	Araria	RÁI	*Rái*	Rough, early subrace; sample clean.
"	"	"	"	SARSON	*Sarsoo*	Pendent, 4-valved, seeds very large, all white, sample clean.
"	"	"	"	TORI	*Tori*	Shorter, earlier kind; sample clean.

Province.	*Division.*	*District.*	*Subdivision.*	*Mustard.*	*Names sent.* *	*Remarks.*
1	2	3	4	5	6	7
Bihar ...	Bhagalpur ...	Purnea ..	Sadar ...	Rái ..	*Raichi*, "Mustard" ...	Tall, late subrace; sample clean. The name sent, being in form diminutive, was not appropriate to the plant.
" ..	" ...	" ...	Kishanganj ...	Sarson ...	*Tara*; "Mustard" ...	Pendent, 2-valved, with placentas normal and replum complete, one of the most important samples as being a connecting link between *S. glauca* Roxb. and *S 3-locularis* Roxb.; seeds white; sample clean.
" ..	" ...	Malda ..	Srichanpur ..	Rái ...	*Rái* ...	Tall, late subrace; sample clean.
" ..	" ...	"	" ..	Tori ...	*Sarishá* ...	Taller, later kind; sample clean.
" ...	" ...	Sonthal Parganas.	Godda ...	Rái .	*Gota* ...	Rough, early subrace; sample clean.
" ...	" ...	" ..	" ..	" ...	*Rái* ...	Tall, late subrace; sample clean.
" ...	" ...	" ...	" ..	Sarson ...	*Sarishá* .	Erect, 2 valved; seed white; sample clean
" ...	" ...	" .	Jamtara	Rái ...	*Mán sarishá* ..	Smooth, early subrace; sample clean.
" ...	" ...	" ..	Rajmahal ...	Sarson ...	*Purbi sarishá* ...	Pendent, partly 4-valved and partly 2-valved with many intermediate forms; seed white
" ...	" ...	" ..	Dumka ..	" ...	*Tharia*; "Mustard" ...	Erect, 2-valved, white-seeded, 90 %; mixed with 10 % rough, early *Rái*.
" ...	" ...	" ..	" ..	Tori ..	*Lutni*; "Mustard" ...	Taller, later kind; sample clean.
" ...	"	" ...	Jirmabari .	" ...	*Mágha sarishá*; "Mustard."	Shorter, earlier kind of *Tori*, 60 %, mixed with about 40 % of tall, late *Rái*
Chota Nagpur	Chota Nagpur	Hazaribagh ..	Hazaribagh ..	Sarson ...	*Sarson* ..	Erect, 2-valved; seed white; sample clean.
" ...	" ...	" ..	" .	Tori ..	*Lutni* ...	Shorter, earlier kind; mixed with it some plants of *Sarson* (erect, 2-valved) and a few plants of *Rái* (rough, early subrace).
" ...	" ...	" ...	" .	" ...	*Rái* ..	Shorter, earlier kind; clean sample (not a single plant of *Rai* in the plot).
" ..	" .	Lohardaga .	Lohardaga ..	Sarson ..	*Sarso*; "Mustard" ...	Erect, 2 valved, seeds 95 % white, 5 % brown,
" ...	" ...	" ...	" ...	Tori .	*Lutni*; "Rape" ...	Taller, later kind; sample clean.

"	"	"	Palamau	SARSON	*Sarson*; "Rape"	Pendent 4-valved, seeds white 75 %; mixed with erect 2 valved white-seeded *Sarson* 20 % and tall late *Rái* 5 %.
"	"	"	"	TORI	*Lutni*; "Mustard"	Taller, later kind; sample clean.
"	"	Singhbhum	Chaibassa	RAI; SARSON	*Rái*	Erect 2-valved, white-seeded *Sarson* and rough, early *Rái* in equal parts.
"	"	"	"	TORI	*Lutni*	Taller, later kind; sample clean.
"	"	"	"	"	*Chota sarishá*	Shorter, earlier kind, sample clean.
"	"	Manbhum	Manbhum	SARSON	"Rape"	Erect 2 valved, seed white; sample clean.
"	"	"	"	TORI	"Mustard"	Shorter, earlier kind; sample clean.
Orissa	Orissa	Balasore	Balasore	"	"	Ditto; ditto.
"	"	Cuttack	Kendrapara	"	*Kala sarishá*	Taller, later kind; sample clean.
	"	"	Angul	RÁI	*Chota sarishá*, "Mustard"	Tall, late subrace, sample clean.
"	"	"	"	SARSON, TORI	*Ganga Toria sarishá*; "Mustard."	Erect 2-valved, white-seeded *Sarson*, and taller later kind of *Tori* in equal amounts
"	"	"	"	TORI	*Bur sarishá*, "Mustard"	Taller, later kind, sample clean.
"	"	Puri	Puri	"	*Sarishá*	Ditto, ditto.
Bengal	Burdwan	Bankura	Vishnupur	RAI	*Lutni*	Rough, early subrace, sample clean.
"	"	"	"	SARSON	*Seti* or *Piyala sarishá*	Erect 2 valved and erect 4-valved in equal amount, seed 90 % white, 10 % brown.
"	"	"	"	"	*Rái or Jhanti sarishá*	Erect 2-valved and erect 4-valved in equal amount; seed 90 % white, 10 % brown.
"	"	Hooghly	Serampore	RAI	*Kala sarishá*	Tall, late subrace; sample clean.
"	"	"	Jahanabad	"	*Jhuni*	Ditto, ditto.
"	"	"	"	TOPI	*Bhunri*	Taller, later kind; sample clean.
"	"	Birbhum	Suri	SARSON	*Sheti sarishá*	Erect 2-valved, seed 90 % white, 10 % brown.
"	"	"	"	TORI	*Lutni* or *Mághi*	Shorter, earlier kind; sample clean.
"	"	Burdwan	Khandghosh	RÁI	*Rai*	Rough, early subrace, sample clean
"	"	"	"	"	*Mái* or *Mághi*	Ditto, ditto.
"	"	"	Mangalkot	SARSON	*Dhepo seti*	Erect 2-valved and erect 4-valved in equal parts; seed all white, very uniform.
	"	"	"	TORI	*Sanchi*	Shorter, earlier kind, sample clean.
"	"	"	Cora	"	"Mustard"	Ditto, ditto.
"	"	Midnapore	Midnapore	RÁI	*Rái sarishá*	Rough early and smooth early subraces in almost equal proportions.
"	"	"	"	"	*Marhi sarishá*	Smooth, early subrace, sample clean.
"	"	"	"	TORI	*Sadharan sarishá*	Shorter, earlier kind; sample clean.

PROVINCE.	Division.	District.	Subdivision.	Mustard.	Names sent.	REMARKS.
1	2	3	4	5	6	7
Bengal	Burdwan	Midnapore	Garhbeta	SARSON	*Sheti Rái*	Erect, 2-valved; seeds white; sample clean.
"	"	"	"	SARSON; TORI	*Sadha bháta Rái*	Erect, 2-valved and erect 4-valved *Sarson*, each 30 %, taller late *Tori* 40 %.
"	Presidency	24-Parganas	Alipore	RÁI	*Kazli sarishá*	Rough, early subrace; sample clean.
"	"	"	"	TORI	"Mustard"	Shorter, earlier kind; sample clean.
"	"	Nadia	Dimukdia	RÁI	*Rái*, "Rape"	Smooth, early subrace; ditto.
"	"	"	Sadar	TORI	*Sarishá*, "Mustard"	Taller, later kind; ditto.
"	"	Jessore	Narail	RÁI	*Maghi sarishá*, "Mustard."	Tall, late subrace; ditto.
"	"	"	"	"	*Rái*, "Rape"	Ditto, ditto.
"	"	"	"	SARSON	*Sheti sarishá*, "White Mustard."	Erect, 2-valved; seeds all white.
"	"	Murshidabad	Jangipur	RÁI	*Rái*	Tall, late subrace; sample clean.
"	"	"	"	TORI	*Sarishá*	Tall, late subrace; sample clean.
"	"	"	Kandi	RÁI	"Rape"	Rough, early subrace; sample clean.
"	"	"	"	TORI	*Jema Sarishá*, "Mustard"	Taller, later kind; sample clean.
"	"	"	Sadar	SARSON; RÁI	*Seti*; "rape"	Erect, 2-valved, white-seeded *Sarson* 60%; tall, later *Rái* 40%.
"	"	"	"	TORI	*Bháti Sarishá*; "Rape"	Shorter, earlier kind, sample clean.
"	Rajshahi	Rajshahi	Naugaon	RÁI	*Rái*	Tall, late subrace; sample clean. Stems very dark purple.
"	"	"	"	SARSON	*Seti Sarishá*	Erect 2-valved and erect 4-valved in about equal proportions; seeds all white.
"	"	"	"	TORI	*Sarishá*	Shorter, earlier kind; sample clean.
"	"	Dinajpur	Alakhi	SARSON	*Taro Sarishá*	Erect 4-valved, seeds white. Poor sample, which germinated badly.
"	"	"	Marnai	TORI	*Sarishá*	Taller, later kind; sample clean.
"	"	"	Natuaganj	"	*Toori*	Shorter, earlier kind; sample clean.
"	"	Rangpur	Badarganj	RÁI	*Rái Sarishá*	Tall, late subrace; sample clean.
"	"	"	Gaibanda	SARSON	*Dhepa Sarishá*	Erect 4-valved; seeds 80% white, 20% brown.
"	"	"	Nilphamari	"	*Seti Sarishá*	Erect 4-valved and pendent 4-valved in about equal proportions, with many intermediates between these two subraces; seeds all white.

„ ...	. ...	„ ..	Kurigram ...	Tori ...	*Mághi Sarishá*	..ind; sample clean.
„ ...		„ ..	„ ...	Sarson ...	*Sheoa Sarishá*	..ved; seeds all white.
„ ...	. ...	Jalpaiguri ..	Phalkota ...	Tori ...	*Kazlia*; "Mustard" ..	..ind; sample clean.
„ ...	„ ...	„ ...	Devganj ...	Rái ...	*Rai* .. .	..ace; sample clean.
„ ...	„ ...	„ ...	„ ...	„ ..	*Rái Sarishá*	..ubrace; sample clean.
„ .	„ .	„ ...		Sarson .	*Swet Sarishá*	..lved; seeds 95% white.
„ ...	„ ...	„ .		Tori ...	*Shewa Sarishá*	..ind; sample clean.
„ ...	„ ...	„ ..	Jalpaiguri ...	„ ...	*Mághi Sarishá* . .	..r kind, sample clean.
„ ...	„ ...	Darjeeling ...	Siliguri ...	„ ..	*Kazlia*, or "purple"	..nd; sample clean.
„ ...	„ ...	„ ..	„ ...	„	*Toori*, or "black" *Sarisha*	..kind; sample clean.
„ ...	„ ...	„	Kurseong ...	Sarson; Tori	*Sarsoo*	..ved, white-seeded *Sarson* .. later *Tori* in equal ..oth ripened well.
„ ...	„ ..	„ ...	Kalimpong ...	Gurkhali Rái	*Rái*	..*a* Roxb.] Did not ripen
„ ...	„ ...	Pabna ...	Sirajganj ...	Rái, Tori ...	„	..s and short early *Tori* ..al proportions.
„ ...	Dacca ...	Mymensingh	Sadar ...	Tori ...	*Sarishá*; "Mustard" ..	..r kind, clean sample.
„ ...	„ ...	„	„ ..	Rái ..	*Rái*	..ace, sample clean.
„ ...	„ ...	„ .	Netrakona ...	„ ...	*Moghlai* . .	..ace, sample clean ..ved 75% mixed with ..d 25%; seeds all white.
„ ...	„ ...	„ .	„ ...	Sarson ..	*Sweti Sarishá* ...	..race; sample clean.
„ ...	„ ..	„ ..	Jamalpur ...	Rái ...	*Ti*	..1, 60% tall white-seeded ..0% considerably shorter
„ ...	„ ...	„ ...	„ ...	Sarson ...	*Dhupi Sarishá* ...	..d plants, exactly like ..*bra* of Shahabad.
„ ...	„ ...	Dacca ..	„ ..	Tori ...	*Mághi Sarishá* . ..	..er kind; clean sample.
„ ...	„ ...	„ ...	Munshiganj .	Rái ...	*Rái Sarishá* . ..	..race; sample clean.
„ ...	„ ...	„ .	„ ..	Sarson ...	*Swet Sarishá*, "Rape." ..	..ed, seeds white, sample
„ ...	„ ...	„ ...	„ ...	Tori ...	*Maghi Sarishá*, "Rape."	..er kind; sample clean.
„ ...	„ ...	Faridpur ..	Sultanpur ...	Rái ...	*Rái Sarishá*	..race, sample clean.
„ ...	„ ...	„ ..	Sobharanpur ...	Tori ...	*Mághi Sarishá*	..er kind, sample clean.
„ ...	„ ...	Backergunge	Gurnadi ...	Rái ...	*Kala Sarishá*	..ace, sample clean.
„ ...	„ ...	„ ...	Habiganj ...	„ ...	*Rái Sarishá* .. .	Ditto; ditto.
„ ...	„ ...	„ ...	Barisal ...	Sarson ..	*Makhan Dhaná Sarishá*	Erect, 2-valved; seeds white, sample clean.
„ ...	„ ...	„ ...	„ ...	Tori ...	*Mághi Sarishá*	Shorter, earlier kind, sample clean.
„ ...	„ ...	Tippera ...	Kotwali ...	Rái ...	*Rái Sarishá*	Rough, early subrace, sample clean.
„ ...	„ ...	„ ...	„ ...	„ ...	*Mághi Sarishá*	Ditto, ditto. In all probability the name is a mistake.

Province.	Division.	District.	Subdivision.	Mustard.	Names sent.	Remarks.
	2	3	4	5	6	7
Bengal ...	Dacca ...	Tippera ..	Kotwali	SARSON	*Dhone Sarishá* . ..	Erect, 2-valved; seeds white; sample clean.
Chittagong ...	Chittagong ...	Noakhali	Sudaram .	SARSON; RÁI	*Dhone Sarisha* .	Erect, 2-valved, white-seeded *Sarson* 90%, *Rái* 10%.
" ...	" ...	Chittagong ...	Raojan Tahsil	RÁI	"Small *Rái*" . .	A mixture in almost equal parts of the "rough early" and the "smooth early" subraces of *Rái* or of plants not botanically distinguishable from these. But the seeds were brighter red in both than in any other sample of *Rái*, and both ripened as late as the tall late subrace from elsewhere.
" ...	" ...	" ...	"	TORI .	*Sarishá* ..	Shorter, earlier kind; sample clean.
" ...	" ...	" ...	Cox's Bazar	"	"Reddish Rape" ...	Ditto; ditto.
" ...	" ...	" ...	Sadar	"RAPE", TORI	"*Mustard*" ...	*A mixture* in equal parts of shorter earlier *Tori* and of a plant, sent from no other district, branching freely from the base, with foliage like that of *Sarson*, but with pale red seeds *smaller* than *Tori* seeds, and *hardly* larger than those of *Rái*.

SECTION V.—RELATION OF NAMES BY WHICH *RÁI, SARSON*, AND *TORI* ARE KNOWN IN BENGAL TO DISTRICTS IN WHICH EACH IS GROWN.

1. [illegible] all the divisio [illegible] where it is pr [illegible], came from Singhbhum, with the name *Rai*, but the plants raised from the seed sent were in equal parts *Sarson* and an early *Rái*, and a second sample sent as *Rái* from Hazaribagh, proved to be *Tori* mixed with *Sarson*

The two earlier subraces, common in the eastern districts of Tirhut and extending into Jalpaiguri, are cultivated [illegible] West [illegible] rga- [illegible] are [illegible] A; [illegible]

The taller later subrace, quite absent from Chittagong and Tippera, and altogether wanting in Chota Nagpur, is present in every other Division, though it has not been reported from Northern and Central Tirhut (Champaran, Darbhanga, and North Bhagalpur)—(MAP I, SECTION A; area within blue line).

The usual name for *Rái* in the Lower Provinces is *Rái*, occasionally given as *Lahi* (Saran) or *Li* (Mymensingh). Of the samples that proved to be really *Rái*, twenty-six bore this name. In dealing with the variants, it will perhaps be most convenient if the divisions are taken in detail.

TIRHUT.—In West Tirhut (Saran and Muzaffarpur) the [illegible]

subrace, but it was not at all applicable to the Purneah sample, which was the finest, tall, late subrace. The same name comes from Monghyr. There, however, it is applied to *Tori*, a usage that one can easily understand if the plant itself be what is thought of.

SOUTH BIHAR.—From Shahabad (Bhujpur) the three different subraces are sent and are carefully distinguished: tall late is *Rái*, rough early is *Lahi Tori*, smooth early is *Langri* [illegible] the "rough early" and [illegible] reported—the former as [illegible] The name *Lutni* (dwarf)

is not particularly applicable to any *Rái*, though it is used

under its proper name *Rái*, and the same subrace is sent from Monghyr, but under the names *Gota* or *Tori*. If *Gota* means "entire," it is not easy to see how it is applicable in this connection. The same name is used with a sample of 'rough early *Rái*' from the Sonthal Parganas.

Orissa.—The name sent with a sample from Angul of 'tall late' *Rái* is *Chota Sarisha*. The *Bor Sarisha* sent from the same place is the dwarf *Tori;* the names therefore apply to the seeds, not to the plants. The plants of this *Rái* were 5 feet high, and were twice the height of those of the *Tori;* the seeds on the other hand were, weight for weight, *Tori*, 34 = *Rái*, 60 or thereabouts.*

[illegible] r and *Chota*, [illegible] f the names [illegible] just possible [illegible] e *plant*, the expression of oil from the seeds is a local industry that absorbs the whole of the seeds there grown; the seeds being a purely domestic article receive an attention subordinate to that bestowed on the plant. In districts where the seeds of [illegible]

out this suggestion.

Coming now to Bengal Proper, we find that the same state of confusion prevails.

West Bengal.—From the Sonthal Parganas all three [illegible] each is distinguished by [illegible] so here "tall late" is [illegible] as *gota* (the name used [illegible] nooth early' is known as '*Man Sarisha*,' perhaps meaning "our own special mustard." Bankura sends only 'rough early,' and sends it as *Lutni*, which is really the Chota Nagpur name for *Tori;* Burdwan sends two samples of the same 'rough early' subrace, one of them as *Rái* which is an accurate enough usage, the other as *My* or *Moghi;* this last, we shall presently find, is the East Bengal name for *Tori*. Midnapore does not send the 'tall late' subrace at all, but sends both the others, distinguishing the

* The actual numbers in a tolah of seed of the original samples were *Tori* (*Bor Sarisha*) 3,300; *Rái* (*Chota Sarisha*) 5,908.

'rough early' as *Rái Sarisha* and the 'smooth early' as *Moria Sarisha.*

again used with reference to the colour of the seeds; the name occurs also in North Bengal, but it is there restricted to *Tori*. From Jessore come two samples of 'tall late' with names that repeat exactly the Burdwan usage as regards 'rough early;' one is properly termed *Rái*, while for the other the name *Mághi* (restricted in East Bengal to *Tori*) is used. Nadia sends 'smooth early' as *Rái*, and Murshidabad sends 'rough early' as *Téró Sárisha*. This term *Téró* is in North Bengal restricted to *Sarson*.

North Bengal.—Purnea sends both 'tall late' and 'rough early;' the names are most unaccountable, for the 'early' and shorter subrace is termed *Rái*; the 'later,' very tall kind, is termed *Ráichi*. The sample named *Rái* is from the Sadar subdivision; that named *Ráichi* is from Arraria. All the other districts send samples; in every case these belong to the 'tall late' subrace and in every instance they are correctly named *Rái*.

East Bengal.—The samples from all the districts except Tippera were 'tall late' *Rái*; from Dacca, Faridpur, Mymensingh (Sadar), and Backergunge (Habiganj) they were sent as *Rái Sárisha*. One from Mymensingh (Jamalpur) came as *Li Sárisha*, and one from Backergunge (Surnadi) as *Kala Sárisha*, thus repeating the usage in Hooghly. A sample from Mymensingh (Netrakona) was sent as *Moghlai Sárisha*, it differed in no respect from the sample sent as *Rái*. The same name recurred in Tippera, but there it was applied to a sample of 'rough early.' Curiously enough, the only other sample from Tippera was this same 'rough early' subrace, and it was named *Rái Sárisha*.

Chittagong.—As from Tippera, only 'early' *Rái* was received from Chittagong under the name "Small *Rái*." The sample was a mixture of both the 'rough' and the 'smooth' early subraces. The name had reference to the seeds apparently, for the only other sample sent from Chittagong as "Mustard" was also a mixture: it consisted of a plant unlike any other Bengal mustard, and most resembling European "Colza," with ordinary *Tori* in about

equal proportions. The seeds of the two are very similar, and are larger than the seeds of *Rái*.

2. *Sarson*, in one form or another, seems to be grown everywhere throughout the Lower Provinces except in Chittagong. It is there replaced by the plant that it seems impossible to separate from true "Colza."

Sarson with pendent pods is, however, very little known or grown. It is, in the two-valved state, restricted to Purnea and Jalpaiguri in North Bengal, crossing the Ganges into the Sonthal Parganas (MAP II, SECTION B; area within blue line). In its 4-valved state this race occupies the same area as the 2-valved, but extends eastward through the whole of Rangpur and northward into British Sikkim (Kurseong subdivision), while it occurs also in the extreme west of our area, in the districts of Shahabad and Palamau (MAP II, SECTION B; areas within red lines). In the intermediate area, Muzaffarpur, etc., it only occurs as a mixed crop along with erect 4-valved *Sarson*. It has not been sent at all from western Tirhut (Saran and Champaran).

Sarson with erect pods is the race usually met with. In its two-valved form (Roxburgh's *Sinapis glauca*) it extends throughout the whole of Chota Nagpur, Orissa, West [illegible] Tippera, but excluding [illegible] area within blue line). [illegible] rom which it has been sent is Shahabad. In its 4-valved form *Sarson* occurs in western Tirhut and south-western Bihar; while absent from the eastern half of Tirhut and from the south-east of Bihar it recurs in North Bengal, where it extends from Dinajpur and Rangpur across the Brahmaputra into Mymensingh (MAP II, SECTION A; area within red line). The two subraces between them thus occupy almost the whole of the Lower Provinces without, however, their areas overlapping, except in the district of Shahabad in South-West Bihar, where the 2-valved Bengal and Chota Nagpur plant crosses into Bihar; also in a narrow strip along the west of Bengal, since one finds that the samples from [illegible] even to Midnapore [illegible] and erect 2-valved. [illegible] l by 4-valved erect- [illegible] ed by the pendent-fruited 4-valved subrace.

Unlike *Rái*, which is cultivated under the same name throughout our area, *Sarson* is known by different names in different Divisions. The name *Sarson* is used throughout Tirhut, South Bihar, Chota Nagpur, and in a modified

form in North Bengal, but it is quite unknown in Orissa, or in any part of Western or Eastern Bengal. The divisions may again most conveniently be taken in detail.

TIRHUT.—Only the 4-valved erect-fruited subrace is grown; always as *Sarson*.

SOUTH BIHAR.—In Shahabad the 4-valved erect and the 4-valved nodding subraces are *Natua Sarson* and *Ulti Sarson* respectively. In Patna the 4-valved erect is *Sarson* also. From Gaya two samples of the same subrace were sent—one from Manghiawan subdivision was named *Sarson*, one from Pariya subdivision was named *Tōra*. A fine suite of samples, sent from Shahabad (Bhujpur), of 2-valved erect-fruited *Sarson* deserves especial notice. One of these samples, with very thick pods, to outward appearance like those of the 4-valved subrace, but with the pods really only 2-valved, was termed *Jowda Sarson*. But other three forms, viz, one with large yellow seeds, one with medium yellow seeds, one with large brown seeds, were termed *Piarka Tōra*, *Piarki Tōri*, *Lalka Tōra* respectively. Here, again, we have the word *Tora*, sent with one of the Gaya samples, used freely as a synonym for *Sarson;* and its use with the yellow-seeded forms—*Tora* for the large, *Tori* for the small-seeded—may indicate the source of the name *Tōri*, which is so commonly applied to the Indian Rape But the usage is not always precise, for even in the present case, though there was sent from Bhujpur a *Lalki Tori*, corresponding to the *Lalka Tōra*, it turned out, as has been already explained, to be 'rough early' *Rái*, and not to be either an Indian Rape or an Indian Colza. A sample from Monghyr, sent as *Sarson*, though mostly 2-valved, had some 4-valved mixed with it.

CHOTA NAGPUR.—From western Chota Nagpur—Palamau, Hazaribagh, Lohardaga—the clean samples were all termed *Sarson*. A sample sent from Hazaribagh as *Rái* proved to be a mixture in about equal parts of *Tōri* and *Sarson*. From Manbhum a sample of *Sarson* was sent, but without any name; from Singhbhum one, sent as "*Rái*," was a mixture of *Rái* and *Sarson*.

ORISSA.—The sample of *Sarson* sent was named *Ganga Toria Sarisha*. Perhaps the name is intended to compare the colour of th [illegible]

WEST BE[illegible]
samples of [illegible]
other simply as *Sarisha*, while a pendent-fruited sample came, from Rajmahal only, as '*Púrbi* (or "eastern") *Sárisha*. From Bankura came two samples, both mixed—erect 2-valved and erect 4-valved. One was named *Sati* or *Piyala Sárisha*,

the other *Rái* or *Jhanti Sirisha*. As the two were identical, it is possible that the second name was sent by mistake. The other samples from West Bengal were sent as *Sheti* or *Sheti Sarisha*, with the exception of two from Midnapore, which came as *Sheti Rái* and *Sadha Bheta Rai* respectively. These are very interesting samples as being the only ones in which *Sarson* is deliberately termed a *Rái*, for the two occasions on which the name *Rái* is associated with samples containing *Sarson* that came from Chota Nagpur must obviously be discounted as the result of ignorance, *Rái* being practically unknown in Chota Nagpur, and the one occasion in which *Sarson* was sent as *Rái* from Bankura was clearly a mistake. The interest is heightened because this is the vernacular term reported for *Sarson* by Roxburgh, both in [illegible] ling to [illegible] *sativa* [illegible] rtainly more usually applied now to *Sarson*. But it need not be con- [illegible] ly was, and [illegible] y him still [illegible] was 2-val- [illegible] d 4-valved.

North Bengal.—The name *Sarsoo* accompanied samples of pendent 4-valved *Sarson* from Purnea and Kurseong; the same subrace from Rangpur was sent as *Sheo Sarisha;* the same name from Jalpaiguri was, however, sent with *Tori*. Pendent 2-valved came from Purnea as *Tara*, from Jalpaiguri as *Sweet Sarisha*. From Dinajpur the name *Téró Sarisha* accompanied erect 4-valved; erect 4-valved from Rangpur was sent as *Dhépá*. From Rajshahi the sample sent as *Seti Sarisha* was mostly erect 4-valved, though there was some 2-valved erect mixed with it.

East Bengal.—Erect 4-valved, which extends into Mymensingh, was sent from Jamalpur subdivision as *Dhupi Sarisha*, and from Netrakona under the usual Bengal name, *Sweti Sarisha*. From all the other districts only erect 2-valved *Sarson* has been sent; from Dacca under the West Bengal name, *Sweet Sarisha*, but from Backergunge as *Makhun Dhane* [illegible]

[illegible]

every other division, and indeed from most of the districts of the Lower Provinces. Strangely neither sort has been sent from Shahabad in South Bihar, or Chapra in Tirhut,

that is to say, from the districts west of the Sone and the Gandak.

The name *Tôri*, which is here used to designate the "Indian Rape," is, like the name for *Sarson*, quite arbitrarily selected as the one by which it shall be known. The reason for adopting it is that it is a familiar word in Hindi-speaking districts. It is, however, in our area used only in Tirhut and South Bihar, and, altered to *Toori*, occurs in the districts of North Bengal nearest to the Terai. In Chota Nagpur this is the mustard known as *Lutni* (dwarf); in Orissa and Western Bengal it is the plant known especially as *Sarisha;* in East Bengal it is the plant known as *Maghi* or *Maghi Sarisha*, owing to its ripening in *Mágh* (January-February). There are, however, especially in West Bengal a number of variants, which will be most easily dealt with if the divisions are considered in detail.

TIRHUT.—From Champaran the taller sort was sent without a name; from Muzaffarpur and Darbhanga it came as *Tôri*. The *Tôri* of North Bhagalpur and Purnea was, on the other hand, the shorter earlier variety.

SOUTH BIHAR.—From Monghyr the West Tirhut form was sent, but the name given was *Ráichi;* from Gaya the shorter earlier form characteristic of North Bhagalpur and Purnea was sent as *Tôri*. It is to be noted therefore that while both forms receive in Tirhut the name *Tôri*, this name in South Bihar is restricted to the more dwarf form, the other receiving a name that in Eastern Tirhut is applied to a form of *Rái*. A consultation of Grierson's admirable work, *Bihar Peasant Life*, chap. xix, p. 246, will show

[illegible]

the Calcutta Herbarium, he experienced the very difficulty that has been met with by Grierson and by the writer; on the figure of his *Sinapis dichotoma*, Roxburgh has himself written the following note:—

"*Shanchi* or *Shorshi* about Calcutta; *Toree* about Purnea; uncertain because *ramosa* and this came up equally plenty from the same parcel of seed sent by Dr. Fleming under the name *Toree*. Now, whether is this or *ramosa* '*Toree*'?"

[illegible]

within the 4-valved area? This is just possible, and it is also possible that the people of Murshidabad may think they have the "bellows-fruited" *Sarsõ*, but are mistaken. Instances of similar mistakes will be indicated further on.

Perhaps a confirmation of this explanation of the meaning is to be found in the use of the same word with reference to *Sola*. In comparing true *Sola* (*Aeschynomene aspera*) with the woody *Sola*, *Kāṭh-Sola* (*Sesbania paludosa*) our country-people often, instead of saying *Sola* and *Kāṭh-Sola*, compare them as *Bhāṭh-Sola* and *Kāṭh Sola*.* The idea, however, underlying the use of the word here is not the shape, but the softness and compressibility of the *Sola* stem, as well as the fact that when squeezed tight the air inside it, if it be compressed under water, escapes in bubbles. It does not, however, seem clear that the word '*bhāti*' is ever used for the "bellows", as such, in Bengal proper.

Bhētā rāi (ভেতারাই); see *Sadha bhētā rāi*.

Bhūṛi (ভুঁড়ি); *Bhunri* of previous chapters. A term received only from Hooghly (Jahanabad) and applied to *Tōri*. The name is evidently used in contradistinction to *Jhuni*, the local name for *Rāi*. It is said to mean "(mustard) preferring a light soil." The words do not appear to be indigenous Bengali terms. The present one is applied to a kind of *awnless* wheat in South-West Bihar (Grierson, *Bihar Peasant Life*, p. 213, § 956); it is also used of *hornless* bullocks (Grierson *loc. cit.*, p. 283, § 1107).

Bar Sariça (ବଡ ସରିଷା). This term is only once used; it comes from Angul in Orissa. It is applied to *Tōri*, which, as a plant, is really much the smallest of the three Bengal mustards. The name *Chōṭā Sariça*, from the same district, is applied to *Rāi*, which is the tallest of the three, but which has much smaller seeds, so that one must conclude that the relativity expressed refers to the seeds, not to the plants. Even then the explanation is not altogether satisfactory, since *Sarsõ* is sent from the same district, and *Sarsõ* seeds are rather larger than *Tōri* seeds. In the present instance only 3,180 *Sarsõ* seeds went to one *tola*, as against 3,360 *Tōri* seeds.

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* NOTE BY DR. HOERNLE.—The "bellows" theory is very plausible. My objection as a philologist is that bellows is spelled either *bhāthi* (भाथी) with *dental th* (as Grierson has it, section 414) or *bhāṭhi* (भाठी) with cerebral *ṭh* (as Bate's Dictionary has it). In any case, the *th* is aspirated, while *your* word is spelled *bhāṭi* (भटि) without aspirate.

The objection is not insuperable. Occasional instances of *t* for *th* are found. The figures certainly suggest bellows.

The *Rāi* sample, however, had 5,908 seeds to a *tola*, and was thus manifestly smaller-seeded. Both *Rāi* and *Tōri* are brown-seeded, the *Sarsõ* being white-seeded Perhaps, therefore, the cultivators only compare the two first, mentally as well as verbally.

Chōṭā Sarıçā (ଛୋଟ ସୋରିଷା).—This term is used twice; in one case, from Orissa (Angul) it is applied to *Rāi*, and is therefore clearly employed with reference to the small seeds; in the other case from Singhbhum (Chyabasa) to *Tōri*, and is therefore clearly employed with reference to the size of the plant.

Ḍhēpā Sarıçā (ঢেপা সরিশা); used once, from Rangpur, with a sample of erect 4-valved *Sarsõ*. The meaning of the term is not clear; it is said to be the same as *Çıētā*, and means, therefore, light-coloured (white or yellow). The sample consisted of four-fifths white, one-fifth brown-seeded.

[illegible]

'very white' or 'pure white.' In this instance the seeds were all white.

Dhanā Sariçā (ধনা সরিশা); used twice, from the adjacent districts of Tippera and Noakhali. The Tippera sample was a clean one of erect 2-valved white-seeded *Sarsõ*; the Noakhali one was the same, mixed with about 10 per cent. of *Rāi*. The name was in both cases transliterated *Dhone*; the meaning possibly is dhan (= dhanya) 'good, auspicious,' or the word may be the *Skr.* धान्य dhānya, = any kind of corn or grain.

Dhupi Sariçā (ধুপি সরিশা); once used, with a sample from Mymensingh (Jamalpur), which was a mixture in equal parts of white and of brown-seeded erect 4-valved *Sarsõ*. The name may be intended to represent the idea conveyed by *dhup* (धूप = incense), and indicate that the odour of the oil is of a superior quality.

Diara Rāi.—This name was sent from Shahabad (Arrah) without a vernacular spelling. The mustard so named was the 'rough early' subrace of *Rāi*. *Diara* is the name given in West Bihar to "fresh land thrown up by the shifting of the course of a river" (Grierson, *Bihar Peasant Life*, p. 162, § 788); the adjective is applied to crops grown on such land.

Gōṭā (गोटा). This name is twice sent: once from Monghyr, with the alternative name *Tōri*, and again from the Sonthal Parganas. It is apparently a very local name; its

meaning is not clear. In *Bihar Peasant Life*, p. 246, § 1055, Grierson mentions the name as applied to *Sarsõ* in the form [illegible]

Gõṭā means "entire, or the reverse of broken"; if so, the term is not particularly apposite. Grierson, however, in another passage [illegible] the Gaya district in a [illegible] this be the meaning, [illegible] the use of the term [illegible]

Gangā Tariyā Sariçā (ଗଙ୍ଗା ଟରିଆ ସୋରିଷା).—This expression is sent with a sample from Orissa (Angul). The name may have reference to the colour of the seeds, comparing them to the colour of the Ganges. But the sample was mixed with white-seeded *Sarsõ* and *Tõri*, so that if this be the explanation, it is not clear to which of the seeds the term applies. *Tariyā* is apparently a local variant of *Tõrā*, *Tori* (*q. v.*).

Jauda Sarsõ.—A name sent from Shahabad (Arrah) without the vernacular character. The form was a *Sarsõ* with erect pods, thick and swollen, as in the 4-valved kinds, but with the pods nevertheless normally 2-valved and with a complete partition dividing the fruit into two chambers. The meaning of the term has not been ascertained.

Jēmõ Sariçā (জেমো সরিষা); sent as *Jema*. Only once received, from Murshidabad (Kandi). The mustard was pure *Tõri*. Some of the writer's native informants suggest that *Jēmõ* means "edible;" if so, the word does not appear to be a Bengali one.*

Jhā̃ṭi Sariçā; Rāi or (ঝাঁটি সরিষা).—There is some confusion about this sample, which came from Bankura (Vishnupur) along with another termed *Siṭi* or *Piyālā Sariçā*, and a third termed *Laṭni*. The *Siṭi* was, as a matter of fact, the same as the *Sheti* of Bengal generally, common *Sarsõ*; but so was the present sample. The sample termed *Laṭni* (which is the Chota Nagpur term for *Tori*) was in reality a clean sample of rough early *Rāi* and not *Tõri* at all; while the sample termed *Rāi* had no *Rāi* in it. Still it is not impossible that the term sent with the present sample

* NOTE BY DR. HOERNLE.—Quite possible. In Sanskrit (जेमन) *jēmana* means "eating," "food." Hence Hindi *jēvanā* to eat, *jēvan* eating. I have found *jēman* applied to a kind of "spiced fritters."

is really applied to *Rāi*, not only because that name itself is used, but because the alternative name is most applicable to *Rāi*. So far as can be learned, *Jhāṭi* means "branched," with the further implication that the branches lie close to each other and to the main stem, which is exactly the case with *Rāi*.*

Jhuni (ঝুনি).—A term used for *Rāi* in the immediate neighbourhood of Hooghly, Howrah, and Calcutta, but of [illegible]

originally the meaning that *Jhāṭi* bears and that Roxburgh's name "ramosa" was suggested by this fact.†

Kājali (কাজলি); twice used: once from Rangpur and once from Siliguri. Though the name is the same as the following, the usage is different, for both samples were *Tōri;* in North Bengal therefore *Kājali* seems to be used as *Kāla* is used in Orissa; not altogether, however, for two samples of *Tōri* were sent from Siliguri, one of them (the taller later kind) carefully marked '*Kājali* or "purple" *Sariçā*', the other (the shorter earlier sort) marked '*Toori* or "black" *Sariçā*'.

Kājali Sariçā (কাজলি সরিশা); once used, with a sample from the 24-Parganas of common *Rāi*. The name in the neighbourhood of Calcutta is therefore synonymous with *Kala* (black).

Kālā Sariçā (কালা সরিষা); used three times; not, however, uniformly. It has reference to the dark colour of the seeds in each case, but with a Cuttack sample it indicated *Tōri;* with a sample from Hooghly (Serampur) and another from Backerganj it indicated *Rāi*.

Lāhi; Rāi, or (লাহি).—A mere variant of the word *Rāi*, used as an alternative for a sample of that mustard from Chapra.

Lāhi sāg; used in North Bengal for one of the "Cabbage-mustards."

Lalka Tora; Lalki Tori.—The adjectives indicate the colour of the seeds; *Lalka Tora* was a brown-seeded *Sarsō̃*, *Lalki*

* NOTE BY DR. HŒRNLE.—Quite so. The usual form in Hindi is *jhāṛ* (झाड़), which means a twig or sprig; and is a common emblem (mint-mark) on certain coins of native states.

† NOTE BY DR. HŒRNLE.—Your suggestion might be correct. There is a word *jhar* or *jhāṛ* or *jhaṇṭ* or *jhāṇṭī*, which means "shrub, bush, bramble;" almost synonymous with *jhāṛ* or *jhāṛṭī;* and *jhaṛṭ* might form into *jhuṇī*.

Tori was *Rāī*. The terms *Tōrā* and *Tōri* are dealt with further on. It may be noted in passing that though both these plants came from the Dumraon Experimental Farm, neither the one nor the other was the actual *Tori* of the cultivator.

Langri.—A term sent, without vernacular characters, from the Dumraon Farm with a mixed sample of "tall late" and "rough early" *Rāi*. The name, if it be used in the ordinary sense (*lame*), has no obvious significance.

Li Sarishā.—A term, of which the vernacular form was not sent, that accompanied a clean sample of tall late *Rāi* from Mymensingh (Jamalpur). Like *Lāhi* it seems a mere local variant of *Rāi*.

Latni (লটনি).—This term by itself accompanied six different samples ; was given as an alternative name with a

Bengal. The use extends beyond Chota Nagpur, however, for one of the samples so named is from the Sonthal Parga-
Bankura.
efiniteness
which is
the Chota
Nagpur and the East Bengal names are used in preference to the Bihar name *Tōri* or the Bengal name *Sariçā*. In the Sonthal Parganas too, where both *Latni* and *Māghi* are
both are *Tōri*,
the taller kind,
early ripening
supplied, for it
accompanies *Rāi*. As has been already explained, however, the name *Rāi* is given to a Bankura sample of *Tōri*, and the chances are perhaps greater that a mistake has been made by the sender of the samples than that the cultivators do not know *Rāi* and *Latni* (*Tōri*) when they see them.

Māghi Sariçā (মাঘি সরিশা).—This name was used with ten samples. Seven of these, from Rangpur, Mymensingh,

Tippera, indicated *Tōri*, iple, the shorter earlier sent. In no case was any alternative name sent, and it may therefore be taken as the usual, if not the only, name for *Tōri* throughout Eastern Bengal. The name occurs in western districts also. Thus it is

of *Tōri*. But though the name *Māghi Sariçā* is sent also from Jessore, it is there quite misapplied, for it is used with the tall late subrace of *Rāi* that does not ripen till after *Māgh* (January-February) is over From Burdwan the term

Bengal mustards.

Māi (মাই); used only once, for the sample just mentioned, from Burdwan, as an alternative with *Māghi*. The plant was rough early *Rāi*, and the name may be only a local variant. The curious thing is that the name *Rāi* came from the *same* village with another sample of the *same* 'rough early' subrace.

Mākhan dānā Sariçā (মাখন দানা সরিষা).—A name sent from Barisal with a clean sample of erect 2-valved white-seeded *Sarsō*, it describes the seeds well.

Mān Sariçā (মান সরিষা)
(Jamtara) with smooth early
equivalent to the " our o
advertiser.

Māṛi Sariçā (মড়ি সরিষা); sent from Midnapore with the same smooth early *Rāi*, which is the least common of the three subraces in the Lower Provinces. The meaning of the term is not clear.

Māgālāi Sariçā (মগলাই সরিষা); used twice: once from Mymensingh, once from Tippera; in both cases for *Rāi* (*Lāi*). The term is said to mean "*Rāi* introduced by the Moguls."* It is not unusual, in Eastern Bengal especially, to use this prefix for any plant obtained from Upper

* Note by Dr. Hœrnle.—This explanation is plausible enough. Only I find the vernacular is spelled Magalāi, with *a*, instead of *o* or *u*. The Muguls or Moguls are never called "Magals." The *quite* proper form is *Mughal*.

India. In West Bengal it is at times used as a synonym for anything of western origin, even if it be European.

Natwa Sarsõ.—This name was sent from Arrah along with the erect 4 valved white-seeded *Sarsõ* as opposed to the 4-valved with pendent pods, which was termed *Ulti Sarsõ*. The appositeness of the latter name is obvious, but the meaning of the other is not altogether clear. *Natwa* is in Bihar the skeleton bamboo "winder" on which the weaver's thread is wound; and the name is also applied to a stunted bullock, possibly because of his bones showing through the skin as the ribs of the winder show through the yarn; by transference *Natwan* applies also to people in poor health or in poor circumstances. But the meaning in the present case is perhaps direct, for the pods of this kind of mustard are not unlike a "winder" when covered with thread. It can hardly be intended to convey the indirect meaning of poverty, because this happens to be one of the finest kinds of *Sarsõ*.*

Pahari Rāi, Pasai, Palangi.—These three terms are used as alternative names for the cabbage mustard with coarsely-toothed leaves which is cultivated in Sikkim and elsewhere in the Himalayas. It was sent to the Sibpur Farm from Kalimpong merely as *Rāi*.

Piarka Tora; Piarki Tori.—Names received from Dumraon Farm. The English equivalents given were "bold yellow rape" and "yellow rape." Both were erect 2-valved white-seeded *Sarsõ*, the first a very slightly branched and very late sort with exceedingly large seeds, the second was the sort that has been sent from most of the districts of West and East Bengal as *Seti* or *Sheti*. The names, just as was the case with the *Lalka Tora* and *Lalki Tori* sent from the same place, *refer to the colour of the seeds*. The yellow sorts were, however, both *Sarsõ*, whereas one of the brown sorts was *Sarsõ*, the other *Rāi*.

Piyālā (or *Sāti*) *Sariçā* (পিয়ালা, সেটি সরিশা).—An alternative name sent from Burdwan for erect 2-valved *Sarsõ*, of which the seeds were 90% white.

Purbi Sarishā.—This name was received with a sample of pendent-fruited *Sarsõ* from Rajmahal. As this is a form of the mustard not uncommon in North Bengal, but practically

unknown south and west of the Ganges, the name doubtless indicates that it has been introduced from the eastward to the Rajmahal district.

Rāi or *Rāi Sariçā* (রাই, রাই সরিষা).—This is one of the important names sent. In the substantive form (unqualified) it was sent with twenty different samples, and in 15 of these it applied to *Rāi*. These fifteen came from Patna, Gaya, Dumraon, Muzaffarpur, Chapra, Purnea, Malda, Sonthal Parganas, Burdwan, Nadia, Jessore, Murshidabad, Rajshahi, Jalpaiguri (Phalkota), Mymensingh. In the five remaining instances it was more or less misapplied. The Kalimpong sample, termed *Rāi*, was the long-misunderstood *Sinapis rugosa*, the cabbage-mustard of Nepal. The Pabna sample was a mixture of *Rāi* and *Tōri*, but this mixture is quite as likely to have been the result of carelessness in the sender as of ignorance in the cultivator. The Hazaribagh *Rāi* was, however, *Tōri;* the Bankura *Rāi* was *Sarsõ;* the *Rāi* of Singhbhum was a mixture of *Sarsõ* and *Rāi*. The explanation of this confusion in [illegible] 'o be that *Rāi* is practica [illegible]

As a [illegible] *Rāi* was sent five times; two of these, from Arrah, viz., *Diara Rāi* and *Latni Rāi* (this latter not to be confounded with *Latni* proper), were really *Rāi;* so was the sample sent from Chittagong as "small *Rāi*." The *Sheti Rāi* of Midnapore was, however, *Sarsõ*, the *Sādā Bhētā Rāi* of the same district, a mixture of *Sarsõ* and *Tōri*.

The adjective form *Rāi Sariçā* accompanied seven [illegible] Jalpaiguri (Deviganj), [illegible] Tippera. In each case

Regarding the incidence of this name, no dispute is possible. It applies, as said by Roxburgh to *Sinapis ramosa* (*Brassica* [illegible] omson, to *Sinapis* [illegible]

Rāichi [illegible] m of the preceding, accompanied four samples. Its incidence is not uniform. One of the samples, termed *Rāichi Rāi*, received from North Bhagalpur, was one of the shorter subraces of *Rāi*, but the sample from Purnea, termed *Rāichi*, was tall late *Rāi*, and as it happens, consisted of the tallest plants in the whole field! The *Rāichi* of Darbhanga and the *Rāichi* of Monghyr were *Tōri;* as applied to *Tōri* the name is quite appropriate. It will be noticed that the name is restricted to Eastern Bihar (Bhagalpur

Division), and that the people use it for different plants in different districts.

Sādā Bhētā Rāi (সাদা ভেতা রাই).—This name was received from Midnapore. The term *Bhētā* is said to be applicable to anything 'round' or 'globular,' and may allude to the fact that the sample contained erect 4-valved fruited plants with thick swollen pods; the seeds being white explains the use of *Sādā*. But there is nothing very definite about the sample, since it was a mixture of this erect 4-valved *Sarsõ* with *Tori*, which does not have thick pods or white seeds.

Sadhāraṇa Sariçā (সাধারণ সরিশা).—Sent once from Midnapore with a clean sample of *Tōri*. The name means "common mustard." The chief interest of the name is that it appears to explain the term *Sada Rayee*, which is one of the names given by Roxburgh for *Sinapis dichotoma* (*Tori*). No one has been able to understand why Roxburgh should have given this as a name for *S. dichotoma*, since its seeds are never white, and whatever name it may receive, it never is termed *Rāi*. The writer, at least, is satisfied that *Sada Rayee* is simply a mistake for *Sadharā*.*

Chhãchi (ছাঁচি).—This name only came with one sample, from Burdwan. The plant was *Tōri*; this name too possesses the interest of being one of those applied to *Tōri* (*Sinapis dichotoma*) by Roxburgh. The name means "genuine," "excellent," "first class," in the sense in which these terms are used by a European advertiser.

Sariçā (সরিশা).—One of the most important of our terms, being the Sanskrit *Siddhārtha* (सिद्धार्थ) and verbally the Hindi *Sarsõ* (सरसों) or *Sarisõ* (सरिसों). It is usually supposed to denote a light-coloured variety of mustard, *çvēta* (श्वेत), but it is interesting to find that this, whatever it may be elsewhere, is not the usage in Bengal. In a single instance, from the Sonthal Parganas, a sample is sent as *Sariçā*, which is actually as well as verbally the same as *Sarsõ*, and has therefore white seeds. But the eight other samples with which the name has been sent (from Chittagong,

mustard.

*Note by Dr. Hœrnle.—I think your suggestion is probably correct, that *Sada Rayee* is a mistake for *Sadhāraṇa*.

The various qualified uses of the word *Sariça* are recorded throughout the list, and need not therefore be alluded to here.

The form in which the name is given by Roxburgh, who applies it accurately to this mustard, is *Shurshi* in the [illegible] that [illegible] noting a [illegible]

Sarisõ, Sarsõ, Sarsu (सरिसु, सरसों, सरसु).—Though verbally identical with the preceding, this name is applied to a quite different plant. We have seen that on *one* occasion [illegible]

the plant that in Bengal proper is known as *Sariçā.* The forms *Sarsõ* and *Sarisõ* occur throughout Chota Nagpur, [illegible] b [illegible] p [illegible] and at Kurseong.

On three other occasions the name occurs in a modified form—*Jauda Sarsõ, Natua Sarsõ, Ulti Sarsõ;* all three are forms of the white-seeded mustard here described as *Sarsõ.*

It is strange that, although there is just as little doubt as in the case of *Rāi,* as to the plant to which the name *Sarsõ* applies, both Roxburgh and afterwards Hooker and

* Note by Dr Hœrnle.—Scholars may have good reason for what they state. They treat these matters, not from the *botanical,* but from the linguistic point of view.

In Sanskrit the terms *Sarisõ, Sarsõ, Sarsu* do not exist at all. The only term which exists *there is sarṣapa* (सर्षप), of which (and this point is qui[illegible] [illegible]

of the country in the [illegible]

Thomson should have misapplied it. They do not use it for the same plant, however. Roxburgh uses it for *Tori*, a mustard to which it is never applied in the Lower Provinces; Hooker and Thomson use it for *Rāi*, a plant to which it is not applied anywhere in India. The mistake in the latter case has, however, as already explained, been merely the result of the transposition of two passages that are otherwise quite accurate.

Seti, Sheti, Sheti Sariça, Sheti Rai, Swet Sariça, Sweti, are local modifications of the same name *Çvēta*, (श्वेता) applied throughout Bengal to the mustard that in Bihar and Chota Nagpur is termed *Sarsõ*. The name refers to the fact that the seeds are white; it never occurs outside Bengal Proper, just as the name *Sarsõ* never occurs within that province. The name is used as often substantively as adjectively. In the latter case it is only once associated with *Rāi*, this happens with a sample sent from Midnapore. All the other instances of adjective use accompany the word *Sarishā*. It is interesting to note that it is this very uncommon usage which is recorded by Roxburgh, for he gives *Shwet Rāi* as the native name for his *Sinapis glauca*.

Seuyā Sariçā (সেওয়া সরিশা)—transliterated *Sheoa* and *She*[illegible] North Bengal. In one cas[illegible]pplied to *Sarsõ*; in the oth[illegible]d for *Tōri*. What the meaning may be is not clear. The word is applied in Bihar to the briard of wheat and millet; its appositeness here is not evident.

Tērō Sariçā (তেড়ো সরিশা) sent as *Tárá* from Purnea, *Táró* from Dinajpur, and *Tharia* from the Sonthal Parganas. All three were *Sarsõ*, and the name, if it means, as [illegible] "the opposite [illegible] sample, that [illegible]n-turned pods. But there is some doubt about this in the writer's mind, for both the Dinajpur and the Sonthal Parganas samples had up-turned pods with straight, erect fruit-stalks.

Tōrā, Tōri, Turi (तोरा, तोरि, तुरि).—This is one of the important names. The form *Tōrā* is very rarely employed:

* Note by Dr. Hoernle—*Tērō*. I agree with this. *Tērō* is Sanskrit *tiryak*, which means "oblique, transverse, horizontal; crooked, curved." It is applied to animals, as walking "horizontally" compared with the erect position of men.

when it is used, it is applied always to *Sarsõ* or Indian Colza (*S. glauca* Roxb.). The diminutive form *Tōri* is, on the other hand, in common use in Bihar, and there it usually indicates the Indian Rape (the *Latni* of Chota Nagpur, the *Sariçā* proper of West Bengal, the *Māghi* of East Bengal).

The *Tōra* of Gaya was *Sarsõ*, so were the *Lalka* and *Piarka Tōra* of the Dumraon Farm; so too was the *Gangā Tariyā* of Orissa, at least in part.

The *Tōri* of Muzaffarpur, Bhagalpur, and Purnea were *Tōri*, so were the *Turi* of Siliguri and of Dinajpur. But the usage is not altogether uniform in Bihar, though it seems to be fairly so in Upper India; for the *Tōri* of Darbhanga and of Monghyr were both *Rāi*, as was also the *Lalki Tori* of the Dumraon Farm. The *Piarki Tori* of that institution was on the other hand a *Sarsõ* with rather smaller seeds than the *Sarsõ* sent as *Piarka Tora*.

The meaning of the names *Tōrā* and *Tōri* is not clear. Grierson (*Bihar Peasant Life*, p. 172, § 823) quotes a rural rhyme of the Gaya district in which *Tori* is translated "oil-seeds." Perhaps this is all the meaning the words usually convey whatever their origin may be. It is interesting to note a discrepancy in the usage of the diminutive form *Tōri*. Generally applied to Indian Rape, with seeds about as large as those of *Tōrā* (*Sarsõ*) but with the whole plant much smaller, it is at times used for *Rāi*, which is generally a larger plant than *Sarsõ* (*Tōrā*) but has much smaller seeds. We have already seen the same discrepancy in the use of *Chōtā Sariçā* in Singhbhum and in Orissa respectively.*

Ulti Sarsõ (उलटि सरिसा).—Sent from Arrah along with, and in opposition to, *Natwa Sarsõ*. The name was applied to 4-valved *Sarsõ* with hanging pods, and its meaning is therefore clear.

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* Note by Dr. Hœrnle.—Your word *Tōrā* (तोरा) puzzles me. Your three principal words are *Tōrā*, *Rāi*, *Sarsõ*. The two latter I know well, and they have their equivalents in Sanskrit. But *Tōrā* I never heard of outside of your paper, and it is curious that it should not be mentioned at all in [illegible]

SECTION VII.—SUMMARY.

In the Lower Provinces three very distinct mustards are generally cultivated:—

Rai, or Indian mustard, the most important of these, is grown in all the provinces except Chota Nagpur, where it is practically unknown, though it seems to be cultivated to a slight extent in Singhbhum. It is easily recognized by having none of its [illegible] its seeds, which are l[illegible] those of *Tori*, or Ind[illegible] being distinctly rugose, and being reddish brown all over. From *Sarson*, which has white seeds or, less often in Bengal,

Summary.

The seed coat, too, is smooth. The seeds of *Sarson* are *sometimes* considerably larger than those of *Tōri* When this is the case the two are easily distinguished.

There are two kinds of *Tōri*—a taller, rather later, and a shorter, very early, kind. Both kinds, however, ripen well ahead of any *Rai* or any *Sarson*. The earlier kind of *Tōri* does not appear to occur in North-West Tirhut; the later [illegible] here [illegible] ern [illegible] the [illegible] West [illegible] of North Bengal, *Maghi* in the south-eastern districts of North Bengal and throughout East Bengal. The Bengal name *Sarishā* recurs in Chittagong.

SARSON, or Indian Colza, occurs in every province except Chittagong, where it is replaced by a different mustard. It is easily distinguished from *Rai* by its stem-clasping leaves [illegible] hished readily from those of *Rāi* by the larger size and the smooth seed-coat; from those of *Tōri* by their being of a lighter brown, and by not having a paler spot at the base of the seed.

There are two races—one with erect pods, the *Natwa Sarson* or *Sarson* proper, and one with pendent pods, the *Ulti* or *Tērō Sarson*. Each race has two distinct subraces—one with 2-valved, the other with 3—4-valved pods.

The forms with hanging pods are not common except in North Bengal and East Tirhut (Purnea), the subrace with 2-valved pods being almost confined to this area. But the 4-valved kind extends sparingly through Western Tirhut, and crossing the Ganges spreads southwards through South-West Bihar a [illegible]

The forms [illegible] everywhere: the 2-valved subrace, however, is little known in Bihar, though it is grown both in Shahabad to the south-west and Monghyr to the south-east. It extends over the whole of Chota Nagpur and over Orissa and West, Central, and East Bengal. The 4-valved subrace occupies West Tirhut and West Bihar, extending thence sparingly through South-East Bihar and along the dry parts of West Bengal, as far south as Midnapore. It also occupies North Bengal

B. 799—855.

and the northern part of East Bengal (Mymensingh), to the exclusion of the 2-valved subrace. Roughly speaking therefore, the 2-valved erect subrace is characteristic of Chota Nagpur, Orissa, West, Central and East Bengal: the 4-valved erect sub-race is characteristic of the western half of Bihar, and again of North Bengal, while the pendent subraces occupy the region between the areas to the north of the Ganges occupied by the erect 4-valved subrace.

The name *Sarson* prevails in Chota Nagpur, in Bihar, and in extreme North Bengal. In Bengal Proper this is the mustard known as *Sweti Sarishá*, or simply *Sweti*. In *Orissa it is Ganga toria.*

There are two other field-mustards cultivated. One of these, confined to Chittagong, seems to be a form of the true or European Colza; the other, or Nepalese mustard, is the same [illegible]

mustard, *Lahi Ság*, is grown throughout North Bengal; this last is a Cabbage-mustard, in habit very like, but still very distinct from, the Nepalese Cabbage-mustard.

As regards the relationship that our three staple mustard-oil crops bear to the corresponding crops in Europe, it may be tentatively held:—

(1) that *Rái* (*Brassica juncea*) is a crop not grown in Europe, at any rate on a commercial scale, but that it takes the place here of *B. nigra* and *B. alba*, which in turn are not grown in India;

(2) that *Sarson* (*B. campestris* VAR. *Sarson*) is a crop not grown largely, if at all, in Europe, but that in India it takes the place both of *B. campestris* VAR. *oleifera*, and *B. Rapa* VAR. *oleifera*, which in turn are hardly ever met with here: finally,

(3) that *Tori* (*B. Napus* VAR. *dichotoma*) seems to be the same plant as *B. præcox* (Summer-rape), or if not the same is at least very like and very near it, and is undoubtedly the plant that in India takes the place both of *B. præcox* and of *B. Napus* VAR. *oleifera*.

B. 799—855.

W. M. D'C.—Reg. No. 7790J—2,200—24 6-98.



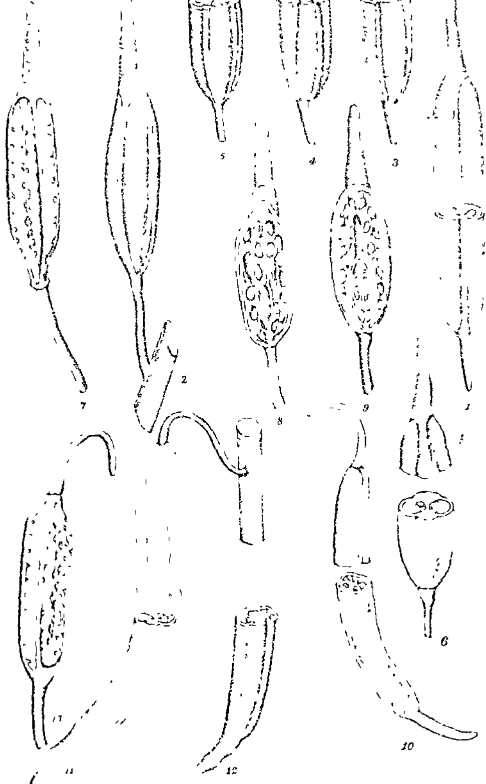

5
6
7


aon, Bengal Mustards
PLAT
1
3





BRASSICA CAMPESTRIS Linn Var SARSON Prain
SINAPIS TRILOCULARIS Roxb



BRASSICA CAMPESTRIS Linn Var SARSON Prain




PLATE X
1
3
3
4

SIKKIM
TIRHOOT
PURNEAH
N BENGAL
S BEHAR
E BENGAL
TIPPERAH
CHITTAGONG
CHOTA NAGPUR
W BENGAL
ORISSA

RAI

Tall, late

Shorter, early

SIKKIM
TIRHOOT
PURNEAH
N BENGAL
S BEHAR
E BENGAL
CHOTA NAGPUR
TIPPERAH
CHITTAGONG
W BENGAL
ORISSA

TORI

Taller, later

Shorter, earlier

D Prain delt

A C Mukerjee lith.

TIRHOOT
N
BENGAL
S BEHAR
E BENGAL
CHOTA NAGPUR
BENGAL
CHITTA
GONG
ORISSA
SARSON

TIRHOOT
N
BENGAL
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THE

AGRICULTURAL LEDGER.

1898—No. 2.

SOILS.

(INDIAN SOILS.)

[*DICTIONARY OF ECONOMIC PRODUCTS, Vol. VI., Pt. III., S 2260 a.*]

ON THE COMPOSITION OF INDIAN SOILS.

A Note by DR. J. W. LEATHER, *Agricultural Chemist to the Government of India.*

Other PAPERS that may be consulted:

The Agricultural Ledger, 1893, Nos. 12 and 13; 1895, No. 14; 1896, Nos. 1, 33; 1897, Nos. 5, 7, 13.



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1. The subject of Indian soils was dealt with by Dr. Voelcker in Chapter 5 of his Report, and in that chapter the following matters are discussed:—

Dr. Voelcker's Report Chapter V Synopsis of contents

(a) the composition of Indian soils, (b) the possible exhaustion of Indian soils, (c) the supply of nitrogen to Indian soils by rain and leguminous plants, (d) the reclamation of certain lands which have become infected by *kans* grass, eroded by surface drainage, or infertile from the presence of salts of sodium called reh.

Of these four subjects, (d) has been dealt with in *The Agricultural Ledger* Nos. 12 and 13 of 1893 and Nos. 7 and 13 of 1897, which deal with Reh and Usar, and No 16 of 1894 describes certain methods of reclaiming Ravine Lands.

Nitrogen in rainfall.

2. Regarding (c), the supply of nitrogen (ammonia and nitric acid) in the rainfall, some determinations have been made by Dr. Van Geyzel in Madras, who found in one year 4 lbs and in

another year 2·1 lbs. nitrogen per acre to be so deposited, and by Mr. Kelway Bamber at Calcutta, who found 3.39 lbs. per acre in the rainfall between May and October. The second part of this subject, namely, the assimilation of nitrogen by certain members of the natural order LEGUMINOSÆ, has been referred to in *Agricultural Ledger* No. 7 of 1894 as well as in many European journals. No work on this subject has been done specially for India; and since it is probable that the part which these plants play in relation to the supply of nitrogen to the soils of India is a very important one, a large field of very useful work remains to future investgators.

Assimilation of atmospheric Nitrogen

The present paper deals principally with the composition of Indian soils. Most of the information here given has been obtained during my tenure of office as Agricultural Chemist to the Government of India. For one section, however, I am indebted to Mr. Kelway Bamber's book on "The Chemistry and Agriculture of Tea," from which I have extracted the information relating to the composition of the Assam tea garden soils.

The subject of the possible exhaustion of Indian soils finds a place at the end of this note.

3. ***The composition of Indian soils.***—In the opening paragraph of his chapter on soils, Dr Voelcker writes: "The soils of India have not so far been made the subject of careful or scientific study. A few analyses are recorded of the soils of particular spots, and on two of the Government experimental farms a practical analysis of the soil has been attempted by growing crops on them. Such experiments have a certain value it is true, but they fall far short of what may be gained by a systematic and scientific enquiry. Again, in paragraph 419, among the subjects which Dr. Voelcker recommends as suitable for investigation by an Agricultural Chemist, is "the sufficiencies and deficiencies of different soils in respect of the various soil constituents." Finally, in paragraph 424 Dr. Voelcker suggests that the Agricultural Chemist might usefully "assist the spread of agricultural education by the preparation of simple text books."

Need for a better knowledge of Indian Soils.

It was indeed more with a view to trying to fulfil the latter recommendation than anything else, that I obtained through some of the Local Governments and others samples of typical soils, and have subjected them to chemical analysis. The completion of this work has been delayed through other duties longer than I had at first

anticipated, and the text book which I had hoped to prepare before the close of the present year will not have been written. The outcome of the work is, nevertheless, a fairly accurate knowledge of the composition of certain types of Indian soils; and considering the almost total absence of any information on the subject and the need there is for it as an aid to agricultural teaching in the several agricultural colleges and schools, the matter contained in the present note will, I doubt not, prove itself of assistance to lecturers.

Besides exhibiting the general composition of the certain classes of soils to be referred to, I have been able, I believe, to explain satisfactorily the cause of the colour of the "black cotton soil" (*regur*), which has been the subject of some little speculation.

4. *Types of Soils.*—As pointed out in paragraph 45 of Dr. Voelcker's Report, the number of main types of soils in India is far smaller, and their position geographically far more readily defined, than is the case with those in England; and although the variations are greater than is suggested by a mere glance at the Geological map of India, it is nevertheless true that one may divide the principal soils of this vast peninsula, which approaches the area of Europe, under about four chief heads, the soils of which are each so perfectly distinct in colour and texture from one another, and stretch uninterruptedly over such very large areas, that such a classification is not only admissible, but essential. It is not, indeed, a matter of distinguishing clays from loams and sandy soils or marls, for each of the principal Indian types of soils includes those which are more clayey and those which contain much sand or gravel, but one rather of distinguishing soils which cannot be confused the one for the other.

Principal Types of Indian Soils.

The four main types of soil to be dealt with, and which certainly occupy by far the greater part of the Indian cultivated area, are the Indo-Gangetic and other alluvium, the black cotton soil or *regur*, the red soils lying on the metamorphic rocks of Madras and the laterite soils which are met with in many parts of India. There are doubtless other minor classes of soils, but they neither possess such characteristic differences in appearance, nor are they distributed over such extensive areas as the four types referred to. For instance, stretches of alluvium have been formed at the mouths of the Rivers Mahanadi, Godaveri, and others, but the area of these [illegible] no

2 a.

Minor classes of Soils.

comparison to the Indo-Gangetic alluvium. Again, I found the soil covering the Dharwar system in the Dharwar District quite different from the *red* soils of the metamorphic rocks in the Madras Presidency.

Probably a more exhaustive study of these various smaller classes of soil might be worth while undertaking. My first aim was, however, to be able to form an idea of the general constitution of the four classes named, to determine in what essential respects they differ from one another, and whether any of them may be said to be usually rich in plant food.

Other soils referred to.

5. In addition to an examination of these main types of soils, analyses of several other descriptions of soil have been undertaken. Ten soils of brown coloured alluvium, principally from the valley of the Cauvery, have been analysed. Six soils from a coffee estate in the Sheveroys have also been examined.

Assam Soils.

From Mr. Bamber's Book on "The Chemistry and Agriculture of Tea" I have extracted much valuable information regarding the composition of the Assam Tea Garden soils.

From these investigations it is possible to set out fairly exactly what are the chief characteristics of Indian soils generally. Several reports on the composition of soils, which constituted enquiries of a special nature, also find a place in this Note.

The soils of the Indo-Gangetic alluvium.

Physical Characters.

6. It is unnecessary to define to what area the Indo-Gangetic alluvium belongs, or to say that, from Karachi on the West to Bengal on the East, one may pass without finding a single pebble ; the only rocky particles larger than sand which this great expanse of land contains, is the nodular limestone which has been called "*kankar*", and which has formed by the deposition of calcium carbonate in the soil within a few feet of the surface. This large expanse of land consists generally of a yellow coloured alluvium, sometimes sandy, sometimes becoming a stiff clay, and the latter is also more of a blue-grey in places. Occasionally, too, sand *duns* or hills have been formed by the wind.

A number of soils which are fairly representative of this alluvial area have been analysed, and these analyses are exhibited in the accompanying Statement No. 1.

Sandy soil.—Among these soils only one (No. 20—93) is a really sandy soil. It was taken from a well cultivated field of what has been called the Ison Sand Belt in the Cawnpur District.

Sandy loams.—Two samples are of sandy loams · The one, No 22—93, is from a very fertile tract lying between the Ison and Ganges, also in the Cawnpur District ; the other, No. 339-94, is a sample of the soil of the Burdwan Experimental Farm, and may likewise be considered a typical sandy loam.

Loams.—The majority of the samples analysed are loams. The first, No. 15—93, is from the Cawnpur District, Nos. 386 & 387—95 are from the Changa Manga Fuel Plantation in the Punjab, No. 33—95 is the surface soil of the new farm at Dumraon, No. 302—96 is the mean of the analyses of two loams from the Bahr Subdivision of the Patna District.

Clays.—The three following samples were more or less clayey soils, though none of them could be considered a stiff clay. No. 41—95 is the sub-soil of the Dumraon (new) farm, No. 299—96 is a clayey soil from the Bahr Sub-division of the Patna District, No. 17—96 is a sample of the soil (surface) from the Sibpur Farm.

Calcareous soil.—Lastly, No. 127—93 is a calcareous soil from Captain Chapman's estate in the Partabgarh District of Oudh. Calcareous soils occur very rarely.

Beds of *kankar* commonly underlie both the alluvium and the *regur*; perhaps similarly other soils. In the case of the alluvium, this *kankar* is only found mixed with the surface soil when the bed of *kankar* is very near the surface. Otherwise the surface soil of the alluvium is remarkably free from this material. In the black cotton soil (*regur*) *kankar* frequently lies in beds a few feet under the surface, but, *in addition*, small pieces of the same material are found intermixed throughout the soil, and in some of these soils the amount of calcium carbonate approaches 10 per cent. Kankar.

[illegible] in the case of those from Captain Cha[illegible]

[illegible]

[illegible] it corresponds to 3·06 per cent. calcium carbonate. The land on Captain Chapman's estate, from which the calcareous sample was taken, is a low-lying area which, until recently, was annually inundated by the river Ganges, and the large amount of lime is doubtless due to the agency of shell-fish.

Of these alluvial soils generally, it may be noted that the amount

Usually more Phosphoric acid in these soils than in other types.

of phosphoric acid, though not large, is frequently more than other classes of Indian soil usually contain.

Nitrogen and organic matter.

The amount of nitrogen and organic matter varies within much about the same limits as in those examples quoted by Dr. Voelcker (paragraph 58). They are low excepting in two cases, the one being the surface soil of the Changa Manga Fuel Reserve, the other the calcareous soil from the reclaimed land at Captain Chapman's estate, and both these have been placed under conditions which are particularly favourable to an accumulation of organic matter and nitrogen.

Comparison with European Soils

In other respects these soils are similar in composition to Euro pean loams and clays. The amount of iron and alumina is perhaps somewhat higher, but the divergence is not great. The sandy soil No. 20 contains 2½ per cent. of each, and in the others the proportion rises, until in the clays it amounts to 6 or 8 per cent. of each. The proportion of magnesia, which varies from ½ per cent. in the more sandy soils to 1½ per cent. in the clays, is perhaps somewhat higher than in English soils generally. It is to be noted that, whilst sulphates are generally absent from the *regur*, the red soils of Madras and the laterite soils, these alluvial soils frequently contain a small amount.

Potash

The amount of potash in those samples in which it was separately determined, varied from ·16 to ·66, which must be considered at least ample if not large.

STATEMENT No. I.

Composition of soils of the Indo-Gangetic alluvium.

	SANDY SOIL.	SANDY LOAMS.			LOAMY SOILS.				CLAY SOILS.			CALCAREOUS SOIL.
	Ison Sand Belt, Cawnpur District	Ison Ganges, Doab.	Burdwan Experimental Farm.	Cawnpur District.	CHANGA MANGA PLANTATION. Compartment Surface soil 1"—3".	CHANGA MANGA PLANTATION. No. I Sub-soil, 3"—15".	Dumraon Farm surface soil.	Bahr Patna District.	Dumraon Farm sub-soil.	Bahr Patna District.	Sibpur, Calcutta	Partabgarh, Oudh.
	20—93.	22—93.	339—94.	15—93	386—95.	387—95	33—95.	302—96.	41—95.	299—96.	17—96.	127—93.
Insoluble silicates and sand	91·72	88·08	84·31	84·84	77·03	86·06	86·82	82·96	80·90	72·64	73·58	57·52
Iron (Fe_2O_3)	2·36	3·10	5·58	4·52	5·74	4·48	4·09	4·59	6·12	7·58	6·36	3·23
Alumina (Al_2O_3)	2·92	4·38	6·09	5·30	4·36	4·36	4·57	5·11	6·50	9·89	7·93	3·39
Manganese (MnO)	...	...	·12	...	·11	·11	·10	11	·14	·14	·11	...
Lime (CaO)	·35	·47	·28	·91	·93	1·03	·30	1·78	2·07	1·01	1·52	14·54
Magnesia (MgO)	·78	·32	·66	·52	1·97	1·48	·76	1·53	1·17	1·64	1·61	1·86
Potash (K_2O)	·33	·64	} ·56	·16	·57	} ·76	} ·48	·66	} ·73	·82	·64	{ ·44
Soda (Na_2O)	·08	·09		·03	·25			·30				·02
Phosphoric acid (P_2O_5)	·08	·08	·04	·10	·19	·9	·08	·13	·08	·07	·11	·18
Sulphuric acid (SO_3)	·04	·05	·02	*Nil*	*Nil*	·03	*Nil*	*Nil*	*Nil*	*Nil*	·03	·08
Carbonic acid (CO_2)	·27	·37	·21	·71	·43	·47	·01	1·10	·05	·28	1·35	11·42
Organic matter and combined water (difference)	1·07	2·42	2·13	2·91	8·42	1·13	2·79	1·73	2·24	5·93	6·76	7·32
TOTAL	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Nitrogen	·027	·081	·042	·046	·237	·043	·049	1·045	·041	·051	·065	·180

Brown alluvial soils from Madras.

Source.

8. A number of samples of brown or greyish alluvial soils have been received from the Madras Presidency, principally from the valley of the Cauvery, and whilst they differ a good deal in colour and texture, still they may be conveniently placed in one class and described together. They are essentially different from the *regur*, the red soils and laterites, and from the alluvium of the Indo-Gangetic Plains. They appear to be free from pebbles, and although the proportion of iron and alumina is high in the loamy ones, not one of them could be considered clayey.

Descriptio of samples.

The Statement No. II. exhibits their composition, and the following are the descriptions which were sent with them.

No. 374—96. "Brown alluvium of great depth from the bed of a ruined tank. Cholum grows nearly 20 feet high on this soil, and the stalks are chiefly used for fuel; the grain produced is more bitter than that produced elsewhere, *hariali* grass (Cynodon Dactylon) grown on this soil is also bitter and fetches a low price in the market."

No. 375—96. "Black loam; lies on a gravelly substratum at a depth of 2 or 3 feet; is therefore unfit for cocoa-nuts. The ryots complain that the soil of this and the neighbouring fields is not retentive enough, and needs to be more frequently watered than the fields further down the Cauvery Valley. Irrigated under the Kaling-arayan channel from the Bhavani."

No. 377—96. "Clay, black; more mellow and clayey than No. 375. At a depth of 3 to 5 feet there is a bed of impalpable black sand, cocoa-nuts and plantains thrive on this remarkably, and nowhere in the Cauvery valley are cocoa-nuts more extensively cultivated. The nuts are comparatively small." (The sample received could not be called either black or clayey; it consisted of a dark brown loamy soil.)

No. 331—96. "Red loam; this is the kind called *yerra masaka* in the Ceded Districts; locally called '*Sempidippu karambai*.'" The sample received consisted of a peculiarly soft dark *brown* soil, inclined to adhere in soft lumps. It will be noted that No. 75—96 (*vide* black soils) is also called *yerra masaka*, but the two are absolutely different in appearance and nature.

No. 381—96. "Loam, pale on the surface, but black below. Though entered in the Settlement Register as black clay, it is fairly

friable, called in Tamil *palpottai*, produces good crops of groundnuts, overlies a calcareous stratum at a depth of more than 5 feet. Description of samples.

No. 384—96 "Loam; retains its natural red colour; as thin as No. 383, taken up for cultivation only a few years ago; less fertile than No. 383."

No. 382—96. "Sandy soil with fine particles; black; uniformly friable to a great depth, has been cropped with *kambu* (Pennisetum typhoideum) every year mixed with ground-nuts in alternate years, *gingelly* following *kambu* in other years; fertile."

No. 383—96. "Loam; natural colour red; but now turned grey having been manured liberally with ashes and canal silt; overlies a bed of sandstone at a depth of 12 to 18 inches; has been cropped with groundnuts almost every year for more than 20 years."

No. 385—96. "Sandy; red soil from the right bank of the Gaddilam river near Panruti; has now turned grey having been plentifully manured with ashes and tank silt; cropped incessantly with ground-nuts and *kambu* for many years; is more than 20 feet deep and is red throughout, except near the surface."

No. 386—96. "Loam; light coloured; has turned grey having been manured plentifully with ashes and tank silt; the soil consists of fine particles and is uniformly friable to a great depth. Has been cultivated with ground-nuts with occasional change of crops for more than 30 years."

Nos. 383 and 386, although described as loams, should be classed as sandy soils.

9. Of these ten soils, all the loamy ones contained high, some of them very high, proportions of iron and alumina. The amount of lime is small excepting in one case, and in no case is there much carbonate of lime. The amount of magnesia is high in five of the samples. The proportion of potash, in those samples in which it was determined, is fairly high, and in no case deficient. Iron and Alumina high. Potash.

Of phosphoric acid the amount is in no case large, and is in much the same proportion as occurs in the other descriptions of soil from Madras. The amount of nitrogen is as small as in most other classes of Indian soils. The amount of volatile matter is high in some cases, but this occurs principally in those soils which contain high proportions of iron and alumina, and is doubtless due to loss of combined water. Phosphoric acid Nitrogen.

Judging by the descriptions they are very fertile soils, but it would appear that they are regularly manured.

STATEMENT No. II.

Composition of brown alluvial soils from Madras Presidency.

	LOAMS.						SANDY SOILS.			
	BELLARY DISTRICT.	COIMBATORE DISTRICT.	TRICHINOPOLY DISTRICT.		SOUTH ARCOT DISTRICT.		SOUTH ARCOT DISTRICT.			
	Hospet Taluk.	Erode Taluk.	Kalitalai Taluk.	Perambalur Taluk.	Chidambaran Taluk.	Cuddalore Taluk	Cuddalore Taluk.			Villupuram Taluk.
	374—96.	375—96.	377—96.	331—96.	381—96.	384—96.	382—96.	383—96.	385—96.	386—96.
Insoluble silicates and sand	57·62	78·46	75·79	66·03	82·33	77·09	95·04	87·61	96·01	93·71
Iron (Fe_2O_3)	17·30	4·84	7·12	10·33	4·84	8·27	2·05	3·46	1·65	2·68
Alumina (Al_2O_3)	10·23	7·97	7·86	15·28	5·85	10·60	1·06	3·89	·90	1·12
Manganese (MnO)	·26	·07	·07	·20	·09	·05	·04	·06	·03	·04
Lime (CaO)	·58	·38	·44	1·23	·32	·05	·15	·10	·09	·18
Magnesia (MgO)	1·82	1·23	1·54	1·87	1·04	·21	·51	·26	·20	·33
Potash (K_2O)	·27	·43	} ·19	·28	} ·98	·10	} ·03	·11	} ·07	·09
Soda (Na_2O)	·38	2·42		·07		·06		·16		
Phosphoric acid (P_2O_5)	·10	·09	·14	·08	·06	·14	·03	·10	·04	·04
Sulphuric acid (SO_3)	...	...	...	...	...	...	...	...	...	...
Carbonic acid (CO_2)	·16	·03	·03	·08	·06	·09	·13	·09	·14	·09
Organic matter and combined water	11·28	4·08	6·82	4·55	4·43	3·34	·96	4·16	·87	1·72
TOTAL	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Nitrogen	·091	·105	·057	·046	·017	·008	·010	·009	·023	0·19

REGUR OR "BLACK COTTON" SOILS.

10. With two exceptions the soils referred to in the accompanying Statement are all true *regur* of *good* quality; the soil from Coimbatore, No. 292—94, and No. 114—95, from Anantapur, are a *bit gravelly.* The following are the descriptions which accompanied the samples. Descriptions of Samples.

No. 380—96. "Black loam; one of the four classes of black cotton soil recognised in Madura and Tinnevelly. It is called *Veppal.* The characteristics are a pale white colour of the surface and such an open texture that it is not fairly retentive. Is several feet deep and rests on *kankar.*"

This is a sample of good *regur* and contains small bits of white *kankar.* It is not clear how the land can have a white colour.

No. 329—96. Madura District, Terumanyalum Taluk. "Black clay; though there had been no rain for a long time, there was moisture 9 inches below the surface."

No. 330—96. Madura District, Terumanyalum Taluk, "Black clay; this is the same as what is called *Choudu regada* in the Ceded Districts, but not quite so hard."

No. 332—96. Trichinopoly District, Perambalur Taluk. "The soil is a black loam not injured by heavy rainfall" (Although this soil is described as a loam, it has all the characteristic appearances of a good "*regur*", and the analysis shows that its composition coincides with the other "*regurs*". The proportion of iron and alumina, though somewhat high, is not exceptional, and the amount of lime normal, as is likewise the nitrogen and organic matter; the proportion of phosphoric acid is very small. I have therefore placed it among the good *regur* soils.

No. 292—94. Coimbatore District, Coimbatore. This soil is a true *regur*, but somewhat less coherent than most.

No. 114—95 Anantapur District. This is described as "Rather inferior black soil". It is also somewhat gravelly and less coherent than most.

No. 248—96. Anantapur District, Gooty Taluk, "*Regur* clay; Nalla Regadi or pure black cotton soil."

No. 72—96. Kistna District, Guntur Taluk. "*Regur* clay (*Banka regada*); known locally as *Kullu regada*, literally rotting regada. It is so retentive of moisture, that crops thrive on it only in years of moderate or deficient rainfall; contains small pieces of limestone

SOILS.	On the Composition of

Descriptions of Samples.

called in Telugu 'Guvarayi'. The larger the proportion of the limestone, the worse the soil is held to be."

No. 73—96. Kistna District, Guntur Taluk. *Regur* clay (*Banka regada*); called locally *Pulludu regada*, literally sour regada. Requires more rain for the successful cultivation of crops than "*Kullu regada*". Contains a larger proportion of "*Guvarayi*". (As a matter of fact the sample received did not contain a larger amount of "*Guvarayi*" limestone, but just about as much as No. 72, to which this comparative remark has reference.)

No. 76—96. Krishna District, Sattenapalle Taluk. "*Regur* clay; the soil is remarkably hard, does not crack in summer so much as the ordinary black cotton soil. Does not easily get softened by immersion in water. Agricultural implements are worn out comparatively soon Indigo leaf, produced from this sort of soil, gives as a rule a larger *proportion of dye than that produced elsewhere. Requires plenty of* rain for the successful cultivation of crops "

(So far as the eye could tell, this soil was a good *regur* of normal quality, and contained but little *kankar* limestone; the analysis is also quite normal.)

No. 77—96. Kistna District, Narsaraopet Taluk. "*Regur* clay; *Krishna regada*."

No. 78—96. Kistna District, Narsaraopet Taluk. "*Regur* clay; *Pulludu regada*. There is scarcely any *guvarayi*."

No. 80—96. Kurnool District, Cumbum Taluk. "*Regur* clay; locally called *Nalla or Krishna regada*."

No. 247—96. Kurnool District, Ramallakot Taluk. "*Regur* clay; cracks much in the dry weather; known as *Accha regadi* or pure black cotton soil."

No. 249—96. Kurnool District, Pattikonda Taluk. "*Regur* clay; a clay soil called locally *Marabhumi*, very hard but retentive of moisture; fertile."

No. 252—96. Cuddapah District, Pulivendla Taluk. "*Regur* clay; called locally *Banka regadi* (that is black clay soil); the cracks were wide and deep."

Nos. 276—96 and 277—96. Nagpur. This is the soil of a plot at the Experimental Farm which has not been manured for a long period of years. A crop of wheat (averaging some 600lbs. of grain per acre) has been taken off it for 12 years.

11. It will have been observed that in several instances the same vernacular name is applied to two or more of the samples For example, Nos. 73 and 78—96 from the Kistna District are both called *pulludu regada;* No. 73 is said to contain "a larger proportion of *gutaraya* (*kankar*) than Kullu regada", whilst No. 78 is said to contain "scarcely any *gutaraya*". In appearance the samples were notably different from one another. The analysis shows that No. 73 contains scarcely any calcium carbonate; No. 78 contains a fairly high proportion. No 72—96 is described as "*banka regada*, known locally as *kullu regada*; No. 73 is called *banka regada*, known locally as *pulludu regada* The former is said to be "so retentive of moisture, that crops thrive on it only in years of moderate or deficient rainfall", whilst No. 73 is said to require "more rain for the successful cultivation of crops than *kullu regada*." Comparison of Vernacular names

One might have expected some difference in the composition of these two soils, such as less iron and alumina or more *kankar* in No. 73, but such is not the case; the composition of the two is as nearly alike as possible.

No. 252—96 is also called "*banka regadi*", but this soil has a composition widely divergent from Nos. 72 and 73.

No. 77—96 is described as "*krishna regada*", No. 80—96 as "*Nalia* or *Krishna regada*", and No. 248—96 as "*nalla regadi*". In composition No. 248 is similar (except in the amount of alkalis) to No. 77, but No. 80 differs considerably from them in several respects.

Thus it would seem that these terms are not related at all to the chemical composition of the soils. Doubtless to the people they have a comparative significance, but if this be so, it is probable that they are related to certain phygical peculiarities dependent as much on the nature of the subsoil or drainage as upon anything else.

12. If the analyses of these 18 *regur* soils be examined, it will be seen that there is comparatively but little variation in their composition. In fact, it is remarkable how uniform their composition is. The individual constituents may with advantage be examined Uniformity of composition of Soils.

Insoluble silicates and sand.—One sample contained only 56 per cent., and two others with appreciably less than 65 per cent.; there is only one which contained more than 75 per cent; 14 samples contained proportions lying between 65 and 75 per cent. Silicates low.

SOILS.	On the Composition of

Iron high.

Oxide of iron.—The majority of the samples contained from about $5\frac{1}{2}$ to $8\frac{1}{2}$ per cent. One sample contained only 4·3; the Nagpur sample contained over 11 per cent., and the one from Trichinopoly District 9·2, but these appear to be extreme limits.

Alumina high.

Alumina.—The greater number of the samples contained from 8·5 to 11 per cent., of alumina. Two samples had only 6·3 and 6·8 respectively, whilst in four others there was 11·8, 12·0, 12·7 and 13·7 per cent., the extreme variation being about the same as in the case of iron. In all the Madras samples there was more alumina than iron by about 1 or 2 per cent. In the Nagpur sample the reverse is the case.

Manganese.—The amount of this constituent is very constant, the lowest amount found being ·09, the highest ·26. In two cases the amount is less than ·12, and in one case it was ·26, but all the other samples contained amounts varying from ·12 to ·25 per cent. of manganese. In the statement of analysis the manganese is entered as manganous oxide. It may be that some part of the manganese exists as dioxide, which I have at least once found in an Indian soil, but the amount of dioxide is certainly not great, and in the presence of organic matters such small quantities are difficult or impossible to detect.

Amount of lime varies.

Lime.—The proportion of lime varies in the samples considerably not only in its total amount, but also in the condition in which it exists.

With one exception it exists in part as carbonate and in part as silicate. In those samples in which there is 2 per cent. or more CaO, the greater part is carbonate; where, however, the total amount of lime is less than about 2 per cent., the greater part exists as silicate. They generally contain from 2 up to 4 or 5 per cent.

Magnesia high.

Magnesia.—The amount of magnesia is high in all samples, and varies from 1·3 to as much as 3·1 per cent. In two samples there is appreciably less than 2 per cent., and three in which it is more than $2\frac{1}{2}$ per cent., namely, 2·6, 2·7 and 3·0; in the remainder of the samples the variation falls between the limits of 2 to $2\frac{1}{2}$ per cent.

Alkalis vary.

Alkalis.—The alkalis vary very considerably, the lowest proportion being ·15 per cent., the highest 2·44 per cent. The amount is, however, in the majority of samples unusually large. In those samples in which the potash was separately determined, it was present

in ample amount for all agricultural purposes and above what is generally found.

Phosphoric acid.—The amount of this valuable plant food is small in nearly all cases. One sample contained ·19 and another ·23 per cent., but in all the remainder the proportion fell below ·1 per cent., and in many cases much below this figure. Phosphoric low

Carbonic acid.—The carbonic acid exists in combination with the lime, and varies to a greater extent even than does that constituent. Apparently the carbonate of lime agglomerates together not only as *beds* of *kankar*, but also as quite small lumps of this material. At any rate many of these soils contain small round bits of *kankar* about the size of mustard seed. Kankar commonly present.

Sulphuric acid.—Most of the samples contained no sulphates, and in no case was the amount anything appreciable. Generally no Sulphates.

Nitrogen.—The amount of nitrogen is very small, as is common to Indian soils generally. The smallest amount is ·012 per cent., the highest ·050 per cent. Little Nitrogen.

13. *Organic matter and combined water.*—The loss in weight which soils experience when heated moderately is occasioned by the combustion of the organic substances, the expulsion of water chemically united with the minerals of the soil, and possibly a little carbonic acid from the calcium carbonate; this latter, however, does not form any material part of the loss. It would of course be interesting to know the amount of organic carbon present apart from the "combined water", but this had to be left undone. A conclusion may nevertheless be drawn concerning its amount. The proportion of "organic matter and combined water" is higher than in most Indian soils. Loss of weight when burnt.

Among the soils representing the Indo-Gangetic Alluvium, one from Changa Manga contained 8·42, and the calcareous soil from Partabgarh 7·32 per cent., but in these the loss was principally due to *organic matter*. Two of the clays suffered about 6 per cent. of loss on heating, which was probably mainly due to combined water. Among the laterite soils, Nos 284, 285 and 358 suffered considerable loss on heating, principally owing to the presence of large amounts of *limonite* which gives up its one molecule of water when heated. Other classes usually lost less than *figure*.

Among the *red soils* from Madras one sample suffered a loss of 7·4 per cent., due principally to combined water. Generally, however, these three types of soils suffered very considerably less loss on heating than did the *regur* soils.

Loss of weight of *Regur* usually high, but not due to organic matter.

On the other hand, when these latter are heated, the loss is almost uniformly high, but there are no indications of any particularly large amount of organic matter. They simply change colour from black to a dark brown. If a soil contain any notable quantity of humus, its combustion can be unmistakably observed.

Reasons.

The proportion of nitrogen is as low in most of these *regur* soils as in other soils which lose only ½ or ⅓ as much when heated. Thus the nitrogen indicates a low proportion of organic matter

Thirdly the manner in which these *regur* soils contract on drying indicates a high proportion of hydrated ferric oxide or alumina, and either of these compounds would lose the water of "hydration" on being heated. The amount of combined water then must be necessarily much higher in these soils than in ordinary ones. A further point may be referred to, namely, that soils, whether in India or elsewhere, which contain a high proportion of organic matter, possess a peculiarly dark brown appearance, approaching black, but nevertheless quite different from the colour of *regur*. Thus it appears certain that the greater part of the loss which these *regur* soils experience when heated is due to expulsion of combined water, and that there is as little organic matter in them as in most other descriptions of Indian soils.

Fertility of *Regur*.

14. Reference may also be suitably made in this place to the question of the fertility of *regur*. At page 412 of the *Geology of India* it is stated that "the fertility of this soil is so great that some of the black soil plains are said to have produced crops for 2,000 years without manure, without having been left fallow, and without irrigation." As to the period named, I do not suppose that Mr. Oldham, when reproducing this statement, assumed there was sufficient evidence to prove that the history of any field is so accurately known that its agricultural treatment can be traced for even as many hundreds of years. But still there is a general belief that these soils are immensely fertile. As to the origin of such a belief, it seems to me that it is due possibly to the fact that the *regur* is usually a more fertile soil than those others which frequently adjoin it, such as the

red soils, which are certainly in many cases light gravelly soils, with rock not far from the surface. The power which *regur* has of retaining moisture is so great, that on this account alone it possesses an advantage over these gravelly red and brown soils situated within the same region as the *regur*.

Effect of the fissures.

Then again one of the results of the strongly contracting power of *regur* is not only that it forms deep and wide fissures in the land, but also the surface literally crumbles to a coarse powder, and a part of this is annually carried by the agricultural implements, the *bakhar* for example, into the fissures, and consequently there is constantly going on *an inversion* of the soil, and what has been subsoil comes to the surface.

These two properties must naturally assist in helping the soil to produce crops. But so far from it being the case that *regur* is inordinately rich, it has been pointed out that, in the matter of phosphoric acid and nitrogen, it is very poor indeed, and if other Indian soils are as poor or even poorer in these particulars than *regur*, one cannot for a moment call it a soil of inexhaustible fertility.

Experience at Nagpur.

The outturn of crops too at the Nagpur Farm on unmanured land is lower than on similar unmanured land of the Gangetic alluvium.

Other published analyses of Regur.

15. In the *Geology of India* (2nd edition), page 411, several analyses of black soils are given. The one made by Dr. Macleod (if even approximately correct) is of a soil very different not only to the samples which I have examined, but also to those the analyses of which are published in the same place. The seven other analyses by Mr. Tween are in some respects in fairly close agreement with mine. The undried soil was employed, and, if the mechanically contained water (7 to 10 per cent.) be withdrawn from the analyses and the remaining items calculated for 100 per cent., the figures would become comparable with mine. The silica varies between the same limits as it did in my samples. The iron and alumina *taken together* are also present in similar amount; but whilst in most of the samples which I analysed there was rather more alumina than iron, in Mr. Tween's analyses there is more iron than alumina in the soils from Seoni and Indore, the other two containing reverse proportions. The proportion of calcium carbonate too is similar. Mr. Tween left magnesia, alkalis, and phosphoric acid undetermined. The amount entered as "organic matter" must have been determined by heating

the soil, since there is no other method available, and thus the combined water is included; this item also agrees with what I found.

Assumed high proportion of organic matters

I have thought it desirable to go into these analyses somewhat in detail, because on their evidence it has been assumed that "there appears always to be a considerable quantity of organic matter combined. The black colour appears to be due either to the carbonaceous elements of the soil or to organic salts of iron". As to there being any inordinate amount of *organic* matter in black soil, I have already shown that there is no evidence in *support* of such a conclusion, but rather much which is antagonistic to it. The second of the above assumptions, namely, that the colour is due to the presence of "organic salts of iron", is one difficult to discuss. It was once suggested to me that the black colour of *regur* was due to the presence of some plant which produced a dye from the root! Such a plant has never, so far as I am aware, been found anywhere. Supposing, however, that such had happened, it is true that a quantity, so small as not to materially increase the proportion of "organic matter", *might* have produced the result. But not only is this a mere assumption, there is, in addition, much evidence of a conflicting nature.

Salts of iron.

Suggested presence of organic dye

Peculiarities of *Regur*.

It is well to bear in mind that these *regur* soils have two peculiarities: the one being the colour, slaty-black to very dark brown-black, the other, the unusual degree to which they contract on drying. The colour of the land frequently varies more or less; sometimes it appears quite *grey*, but this is obviously produced by the presence of *kankar;* sometimes it appears *brown* on the sides of cuttings. But I am convinced that there *is* some constant ingredient of these soils which *is* either black or slaty-black. It *may* be that the black coloured ingredient and the ingredient which causes the strong contraction on drying are identical; it is much more probable that they are *not*. Now, referring to the possible presence of "organic salts of iron", it must be remembered that at the high temperature (often 50°—60° C. or 120°—140° F.) to which the surface soil is subjected in India during long months each year, oxidation *must* be rapid, and doubtless is so, and one cannot imagine any organic salt of iron remaining unoxidised for generations under such circumstances.

Organic salts of iron can hardly be present

Again, supposing some particular plant were constantly producing a dark coloured material, how comes it to do so only in *the* soil which contracts so peculiarly? Our knowledge of plants is that they

do *not* exclusively grow on some particular soil. Thus it is difficult to conceive that the colour is due to organic matter at all.

At page 414 of the *Geology of India* reference is made to Mr Blanford's paper (*Memoirs IV.*) in which he states that he found *regur* being formed in lagoons by the sea In a foot-note at page 135 of *Memoirs IV* (2) Dr King states that the "*regur*" described by Blanford was not true *regur*.

Geologists' opinion as to formation of *Regur*

Again, in the same paragraph of the *Geology of India*, reference is made to Mr. Blanford's paper (*Records VIII.*), in which he points out the similarity between the mud at the mouth of the Tapti and the *regur* of the neighbouring country, and for geological reasons assumes that the former is now being formed, and that the latter was originally formed *by the sea*. I have also seen the same country, and I must say that it appeared to me that the black mud at Surat was simply the silt brought down by the Tapti from the neighbouring *true regur*. The flow of the river is stopped at Surat by the tide, and the mud has an opportunity to deposit itself.

Tapti mud.

Messrs. King and Foote concluded that *regur* was formed in marshes; that the now high lying *regur* was originally submerged. Here again this seems to be a conclusion not warranted by facts. It is true that the mud of marshes in Europe or *jhils* in India is usually dark coloured, a colour due in many cases to organic matter and sometimes to ferrous oxide, or again to the clay being itself grey coloured, but unless due to ferrous iron, the organic matter of marshy land produces a soil of a much lighter brown colour than any true *regur*; the presence of free ferrous oxide is quite out of the question; and lastly the clayey deposits usually formed in *jhils* never has the same black colour nor the extremely high contraction which *regur* possesses.

Mud of marshes and *jhils*.

16. In my opinion one *must* come to the conclusion that the colour of *regur* is *not* due to organic matter. It is much more probable that *regur* has been formed from some particular rock which, on decomposition, forms not only a highly argillaceous soil, but also during disintegration liberates a black or very dark coloured *mineral*. Many geologists have contended that *regur* is the product of the decomposition of trap rocks. Oldham (page 413, *Geology of India*) says this view cannot be maintained because (1) "basalt generally decomposes into a reddish soil quite different from *regur* in character,"

Colour of *Regur* not due to organic matter.

SOILS.	On the Composition of

Several products of Basalt.

(2) he considers that Hislop's view, that the colour of *regur* is due to impregnation of organic matter, is the most probable theory. One must of course admit that basalt *is* decomposing, at least in places, into a red soil, and what is still more puzzling is the fact that, whilst one finds this the case on the steep slopes of the hill-sides, it is just as common to find that *immediately* at the foot of these same slopes comes the true *regur*. Another point may advisedly be borne in mind, namely, it appears to be admitted that *some* of the *laterite* has been formed from trap. It is clear that *some* trap is decomposing into a red soil entirely different from laterite, and consequently if trap can produce two soils so different as these, why should not some descriptions of trap produce the *regur*.

Indian soils usually contain little organic matter.

17. I have referred to this subject somewhat at length principally because I believe there is *no* reason for assuming the colour of *regur* to be due to organic matter; that on the contrary there is every reason for assuming such to be impossible. Not only is the amount of organic matter in *regur* always small, but in no soils from the *plains* of India *which have been regularly exposed to the sun's influence for a considerable time* have I found even what is in Europe generally considered an ordinary amount of humus.

Exceptions.

One soil from Oudh, which until recently was annually submerged by the Ganges, and which has now been reclaimed, contained probably a considerable amount of organic matter; the surface soil from the Changa Manga plantation naturally also contained a good deal of humus, but these are cases of soils having been regularly placed under protective circumstances. Again, the coffee soils from the Sheveroy Hills contained likewise high proportions of the same material, but the temperature in that situation is much below what is common to the plains, and the land is regularly manured and also protected by the shade of the bushes.

Regur contains dark coloured mineral.

And if the colour of *regur* is not due to organic matter, it *must* be due to the presence of some *mineral* substance. As a matter of fact *regur* does contain a dark coloured mineral which I have reason to believe *is* peculiar to this soil. If *regur* be *boiled* with concentrated sulphuric acid for several hours, the insoluble residue is very dark brown. I noticed this peculiarity during the process of determining the nitrogen (the first step of which consists in boiling the soil with concentrated sulphuric acid). I have had portions of a number of

the Indian soils treated in this manner, specially to note *the colour of the silicates insoluble in sulphuric acid, and the following* are the notes I made All were treated in precisely the same way, namely, 10 grammes of the soil was simply boiled with concentrated sulphuric acid for several hours. After cooling water was added and the sand washed by decantation. The colour of the latter was then noted. In the case of Nos. 329, 330, 332, 292, 248, 72, 73, 77, 78, and 249, all good *regur* soils, the silicates were almost entirely very dark brown or black coloured, and white silicates could only be seen with difficulty. Of the soils from the Indo-Gangetic alluvium, the silicates of the Changa Manga soil were nearly entirely white; those of the Burdwan soil were nearly entirely white, but included some little black silicates, the Bahr clay soil contained a good deal of black silicates; that of the Dumraon soil was nearly all white, but included a little black silicate. Among the laterite soils the silicates had the following colour. No. 282 mostly white, little black; No 218, mostly white, some red; No. 280 mostly white, some red, No. 284, *mostly dark red. The red colour of these " silicates " was quite* different from the dark brown of the *regur* soils, and could not be for a moment mistaken for it. The red soils from Madras Presidency yielded silicates of the following colour. Nos. 327 and 291 mostly white, with a little black; No 74 mostly white with some red and black, No. 333 mostly white with some red (like the silicates of laterite); No. 250 contained a good deal of black, and No. 331 mostly black Thus, whilst some of the other soils contained insoluble silicates of a colour similar to that of the *regur* soil, the amount in such cases was always small, whilst, as already observed, the insoluble matter of the *regur* soils was almost entirely very dark brown.

Colour of silicates of different Indian soils

It need hardly be pointed out that during the process of *boiling* the soil with sulphuric acid all organic matter is destroyed, and that the colour of the resulting " silicates " cannot be due to organic matter or to " organic salts of iron."

SOILS. On the Composition of

STATEMENT No. III.

Analyses of Black Soils (Regur).

District.	Madura District.			Trichinopoly District.	Coimbatore District.	Anantapur District.	
Taluk.	Teramanyalam Taluk.			Parambalur Taluk.	Coimbatore.		Gooty.
	380-96	329-96	330-96	332-96	292-94	114-95	248-96
Insoluble silicates and sand	72·68	68·97	72·89	65·16	69·31	78·50	62·15
Iron (Fe_2O_3)	6·09	6·96	6·27	9·27	5·31	4·34	6·25
Alumina (Al_2O_3)	8·39	10·84	10·84	13·76	5·51	6·33	12·06
Manganese (MnO)	·19	·22	·20	·25	·20	·21	·15
Lime (CaO)	2·42	1·96	2·20	2·18	4·62	2·00	5·35
Magnesia (MgO)	1·66	1·90	2·01	2·47	2·44	1·95	2·50
Potash (K_2O) } Soda (Na_2O)	·16	·26					·21
Potash (K_2O)			·23	·14	·47	·43	
Soda (Na_2O)			·37	·01	1·06	·26	
Phosphoric acid (P_2O_5)	·07	·03	·02	Trace	·19	·03	·06
Sulphuric acid (SO_3)	*Nil.*	*Nil.*	·01	*Nil.*	·06	*Nil.*	·03
Carbonic acid (CO_2)	2·00	·25	1·09	·91	2·77	1·71	3·58
Organic matter and combined water (difference)	6·14	8·61	3·87	5·85	5·12	4·24	7·66
TOTAL	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Nitrogen	·019	·030	·025	·024	·027	·016	·043

S. 2260 a.

STATEMENT No. III.—*continued.*

Analyses of Black Soils (Regur).

DISTRICT.	KISTNA DISTRICT.					KARNOOL DISTRICT			CUDDAPAH DISTRICT	CENTRAL PROVINCES.	
Taluk	Guntur.	Guntur.	Sattenapalle	Narsaraopet	Narsaraopet.	Cumbum.	Ramallakot	Pattikonda	Pulivendla.	Nagpur Farm.	
										Surface soil.	Sub-soil
	72-96	73-96	76-96	77-96	78-96	80-96	247-96	249-96	252-96	276-96	277-96
Insoluble silicates and sand	72·32	71·66	70·08	64·92	68·29	71·94	63·74	64·91	56·08	68·71	67·01
Iron (Fe_2O_3)	6·67	6·64	7·04	6·60	6·96	5·60	6·54	6·33	8·74	11·25	11·50
Alumina (Al_2O_3)	8·50	8·74	10·61	10·91	10·20	8·62	11·83	9·99	12·77	9·39	10·41
Manganese (MnO)	·14	·12	·18	·10	·09	·12	·16	·16	·22	·26	·25
Lime (CaO)	1·44	1·16	1·67	3·53	3·43	3·31	3·66	4·90	4·95	1·82	1·76
Magnesia (MgO)	2·06	2·39	2·02	2·55	2·67	1·94	2·78	2·35	3·09	1·79	2·19
Potash (K_2O)	·68	·48 (Potash and Soda)	·68	·79	1·14	·64 (Potash and Soda)	·43	·28	67 (Potash and Soda)	·45	·50
Soda (Na_2O)	·31		·21	·57	1·30		·21	·05			·01
Phosphoric acid (P_2O_5)	·07	·06	·05	·07	·08	·08	·05	·07	·08	·06	·05
Sulphuric acid (SO_3)	*Nil.*	*Nil.*	*Nil*	*Nil.*	*Nil.*	*Nil*	*Nil*	·01	*Nil.*	*Nil.*	*Nil.*
Carbonic acid (CO_2)	·16	·16	·49	1·96	1·88	2·40	2·32	3·15	3·43	·44	·53
Organic matter and combined water (difference).	7·65	8·59	6·37	8·00	3·96	5·35	8·28	7·80	9·37	5·83	5·79
TOTAL	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Nitrogen	·049	·036	·020	·030	·012	·045	·034	·035	·028	·050	·04

18. After obtaining the results here detailed regarding the composition of the *regur* soils, I submitted a copy to the Director of the Geological Survey, and I add here copies of Mr. Oldham's letter on the subject and my reply.

Copy of a Demi-official letter dated 3rd September 1897, from Mr. Oldham *to* Dr. J. W. Leather.

Correspondence with Mr. Oldham

"I return herewith the extract from your report on *regur* with thanks for the favour of being enabled to see it. I trust you will arrange that we are supplied with a copy when printed. As regards your ideas, it is of course impossible to judge fully from a mere extract. To take one point only, I think, from what I have seen, that the dark colour is not due to humus, but an important element in deciding this is the determination of the amount of organic carbon in the soil. From the extract you send it would seem that this was not determined, but this is probably in another part of the report.

The following points, however, struck me :—

(1) With a single exception, none of your samples came from the typical *regur* areas of the Deccan trap plateau in Bombay, Berar and Malwa. The one exception, the sample from Nagpur, is from the extreme limit of the area. The identity of the Madras cotton soils with the true *regur* has been doubted, and as it is to the latter, as developed in the plateau of the Deccan trap, that the Manual principally refers, some of your criticisms are easily explained.

For instance, the divergence you notice between Tween's analyses and yours is due to this. In the districts where his analyses show an excess of iron over alumina, this is, I should say, a general feature, and is in agreement with your single analysis.—Nagpur,—from the same region. The Madras cotton soil I would expect to contain less iron if they agree with the other in mode of origin.

The remark in the Manual about the fertility of the soil has special reference to the region from which you have no samples. I think it is probable that the general impression which it records is explicable as you explain it, but there can be no doubt of the general idea as to the fertility of the soil, an idea which is crystallised in the term Malwa, applied to the great spread of it north of the Nerbada.

(2) Though I think it probable that the dark colour is not due to humus, it might yet be due to organic matter, as organic acids in combination with ferrous salts give dark-coloured compounds—

e g., ink—and a soil composed of decomposing basic minerals would naturally contain ferrous compounds.

(3) The concluding part of your extract is, I must confess, inexplicable to me, for I know of no dark-coloured silicate whose specific gravity is less than any white silicate, and unless our accepted ideas of chemical and physical constitution are erroneous, do not see how such could be the case It seems clear that the particles with which you were dealing could not be silicates, or there must be a slip in your account and you have inverted the behaviour of the black and white particles

These are the three principal points which struck me in reading your note, which is very interesting, but I must regard it as a matter of regret that the absence of specimens from the great and typical area of Berar and Malwa make the report inconclusive, as it deals exclusively with soils which have only been classed with the true cotton soil on the ground of superficial resemblance. Some of these are certainly of a different origin, and apparently quite different in their characters too, and all of them are only to be doubtfully related to the true cotton soil, from which they differ in chemical composition—very probably also in origin"

Copy of a demi-official letter No 159, dated 21st September 1897, from Dr. J. W. Leather *to* R. D. Oldham, Esq., *Calcutta.*

"Thank you for your demi-official of 3rd instant.

Doubtless it would have been an advantage to have analysed more samples of *regur* from the Central Provinces and Berars, but still I have seen these *regur* plains, as well as those in Madras, and so far as one can judge by appearances only, there are no particular differences between them. *Regur* seems to be a soil which is so characteristically different from any other sort of soil, that even when impure, such as when it is merging into another soil on its margin, one cannot have any doubt as to whether a part is *regur* or not. But the samples which I analysed were, so far as I could judge, *pure regur*. In any case the mere variation in the relative proportions of iron and alumina can hardly affect the principal question at issue. For instance, it may be that in one large area, there is more iron than alumina, in another the reverse proportions. I do not see how it can be suggested that the *regur* in Madras is essentially different from that in the Central Provinces and

Berar or Malwa, when the principal physical features of the two are identical!

2. I notice that you still think it possible that the black colour is due to the presence of "organic salts of iron." Well, I can only point out, as I have done in my report, that in my opinion no such compounds could exist under the influences of an Indian climate. The example which you give, namely, *ink*, would become rapidly oxidised

3. Then about the dark-coloured material which I have spoken of as a "silicate." There can be no doubt of its existence, and in another experiment which I made, I again found *white* silicates sink in a dense liquid, whilst the dark-coloured material remained floating. I was of course very much surprised at this, for I naturally expected the black stuff to be the denser.

But apart from this, the most important feature is the fact that these *regur* soils, on being boiled for some hours with concentrated sulphuric acid, remain almost entirely black, whereas all ordinary soils become white with such treatment. The black colour cannot of course be due to carbon."

19. One of the first experiments which I made with the siliceous residue of these *regur* soils, obtained, as already detailed, by the action of concentrated sulphuric acid, was to try to separate the black material from the white.

Separation of silicates of *Regur*.

The method by which such a separation may be effected is briefly as follows. A strong solution of some heavy metallic salt is made which has a greater specific gravity than the silicates concerned. There are several solutions which may be prepared for this purpose. The one which I employed was prepared by dissolving mercuric iodide in a solution of potassium iodide. This had a specific gravity of 2·526 at $\frac{25^\circ C}{4^\circ C}$. Most of the siliceous residue from *regur* floated on the surface of this liquid; that which sank was white. By cautiously adding small quantities of water, or better, of a solution of potassium iodide, the solution becomes less dense, and when a certain point is reached, the densest (specifically heaviest) matter, which had been floating, sinks. I naturally expected that the *black* material would prove denser than the white, and I was much surprised to find that the reverse is the case.

Method.

My Experiments

Several experiments have been carried out with the mixed siliceous matter of a number of these *regur* soils, and the result has proved to be uniformly the same In every case the densest material was white and this sank first.

By carrying out the method of separation in careful steps, the siliceous matters were separated into half a dozen portions, all of which had decreasing densities In the two quantitative separations which are detailed below, the first fraction was nearly white, the second grey, the third, fourth and fifth nearly quite black, and then curiously the last or lightest portion was lighter coloured.

The weights of the materials thus obtained were as follows —

First experiment.—From 2,200 grammes of the silicates, ·558 grammes (white); ·030 (nearly white); ·389 (dark coloured); ·616 (very dark coloured); ·085 (somewhat lighter coloured); ·522 (grey) were obtained.

Second experiment.—From 25·897 grammes of silicates the following fractions were obtained, 3·452 (white); 2·182 (nearly white); 1·333 (grey); 1 656 (nearly black); 6·765 (blackest); 5·425 (dark grey); 5·084 grammes (light grey).

The black material was now subjected to the following further tests.—

(a) Under the microscope it proved to be by no means all black, but the particles consisted of apparently silicate with a red and a black substance fused to them. The quantity of black particles was not by any means so large as one would have expected from the colour of the substance as a whole. But as is well known, it does not require a very large proportion of a black material, when mixed with a white one, to render the whole quite black to the naked eye.

(b) On igniting the black siliceous material it became red. Under the microscope it was observable that the black particles had disappeared.

(c) On treating the black material with concentrated hydrochloric acid at 100° C. for an hour or so, a certain amount of iron is dissolved, but the colour of the whole remains unchanged. Under the microscope it appeared that the black particles remained, but the red particles had diminished greatly.

(*d*) If the black material be first ignited and then treated with concentrated hydrochloric acid at 100° C., practically just the same amount of iron becomes dissolved as was the case with the unburnt black siliceous matter, but whilst the latter remained black, this burnt material became quite white. Under the microscope no red or black particles could now be seen.

Black particles possibly graphite.

There can be little doubt that the black particles are either volatile or oxidisable, but it is doubtful whether they contain any iron at all. The iron which the black siliceous matter gives up on treatment with hydrochloric acid, both before and after ignition, is doubtless also an adhering constituent of it. I have not had an opportunity of carrying the investigation any further. It is possible that the black particles consist of graphite, fused on to the silicates, but this will require to be proved.

These experiments had not been completed when Mr. Oldham saw my manuscript, and they will explain probably that it is quite possible for the dark-coloured siliceous matter to have a less density than the white At any rate, there is not the least doubt that the black particles are in part composed of silica, and also that they have a less density than the white. Otherwise the latter could not have sunk first in the separating fluid.

OTHER "BLACK" SOILS.

20. Among the samples of soil which I have received from Madras are three or four which are either described as "Black Loams" or have a similarity in colour to the *regur*, but which are certainly not *pure regur*. They vary much in composition and appearance. The analyses are set out in Statement No. IV.

No 79-96 is described as "*regur* loam; locally known as *Pati-mannu* which is specially preferred for the cultivation of tobacco and chillies. It is from this sort of soil that saltpetre is manufactured."

Descriptions of samples.

Regarding this remark, I must say that the sample contained no trace of nitrates, and, as will be evident from the analysis, there was very little nitrogen in it at all. It is a very dark-coloured sandy soil containing about 1 per cent. of calcium carbonate, much less iron and alumina and magnesia than *regur;* the amount lost on

heating is also very small, and indeed is a very poor soil in every respect excepting in that of phosphoric acid, of which the proportion is high.

It is not particularly surprising that no nitrates were present, because I imagine that the remark applies not so much to the particular land from which the specimen was selected, as to the fact that nitrates are found in similar soil *in another situation.* But it *is* somewhat surprising that it should be described as a good soil for the cultivation of chillies and tobacco, since land which is retained for the growth of these crops is usually kept in good "heart" by liberal allowances of manure. The assessment is entered as R1-0-0 which is low, and one must assume that *this particular field* is not utilised for the purpose in question, but rather that similar land of other fields are kept for it

No. 328-96 is described as "black loam (called *Nalkali pottal*); it conserves moisture very well. The soil was whitish on the surface. Cotton thrives on it" It is a grey sandy soil containing very little organic matter and nitrogen and phosphoric acid, and one would not have expected it to "conserve moisture well"

No. 251-96 is described as a "red loam; hard and saline and grey coloured; requires light and frequent showers; called locally *Tella kattu nela.*" The term "red" is doubtless a clerical error. It is a grey soil full of fine *kankar* and pieces of rock, but having also something of the appearance of *regur.* Indeed the analysis indicates this, the silicates are low, the iron and alumina high—the proportion of carbonate of lime high (the carbonic acid is equivalent to 6·90 per cent.), the high magnesia, with alkalis and phosphoric acid, loss on heating and nitrogen, all in similar proportion to that in *regur*, in short a composition which could not by itself be distinguished from a good *regur.* It is probable that this is a true *regur* containing enough *kankar* and coarse rock to give it the texture of a loam rather than a good "black cotton soil."

No. 75-96 described as "*regur* clay, locally known as *Yerra masaka.*" The soil had a dark brown colour and differed somewhat in appearance from true *regur*, though doubtless there was some *regur* in it. It has nevertheless a general composition similar to *regur*, and a very fair proportion of phosphoric acid.

STATEMENT No. IV.

Analyses of Black Loamy Soils.

	Kistna District.	Madura District.	Karnool District.	Kistna District.
	Vinu Konda Taluk	Teramanylam Taluk	Patti Konda Taluk	Guntur Taluk.
	79-96.	328-96.	251-96.	75-96.
Insoluble silicates and sand	90 70	82·11	59·45	73 83
Iron (Fe_2O_3)	2 53	5·70	9 08	9·09
Alumina (Al_2O_3)	2 18	5·19	11 86	6 60
Manganese (MnO)	06	·12	·12	·14
Lime (CaO)	1 13	1·10	4·41	88
Magnesia (MgO)	65	1·27	3·18	1·53
Potash (K_2O)	·37	·24	} ·56	} ·20
Soda (Na_2O)	·06	86		
Phosphoric acid (P_2O_5)	·32	·06	·05	·17
Sulphuric acid (SO_3)	*Nil.*	·15	06	*Nil.*
Carbonic acid (CO_2)	·45	93	3·04	·14
Organic matter and combined water (difference)	1 55	2 27	8 19	7 42
TOTAL	100 00	100·00	100·00	100·00
Nitrogen	006	·008	·036	·047

S. 2260 a.

THE RED SOILS OF MADRAS.

21. Several samples of soil of a distinctly red colour have been sent from Madras, and their composition is exhibited in the accompanying Statement No. V.

In the "*Geology of India*," (2nd Edition), page 410, the red soils of India are thus referred to —"The somewhat ferruginous soils common on the surface of many Indian rocks, and especially of the metamorphic formations, would probably never have attracted much attention, but for the contrast they present in appearance to the black soil. They have only been noticed as a rule in papers relating to the black soil country in the Western and Southern portions of the Peninsula. The commonest form of red soil is a sandy clay, coloured by iron peroxide, and either derived from the rock *in situ* or from the same products of decomposition washed to a lower elevation by rain. The term is, however, used in a very vague sense, apparently to distinguish such soils as are not black, and hence many alluvial soils may be comprehended under the general term. In very many cases, too, it appears to have been applied in Southern India to thick alluvial beds of sand or sandy clays, which are in fact ordinary river or rain wash deposits.' Doubtless these remarks had no reference to *laterite* soils, which are not only frequently red, but also of peculiar appearance. But in addition there are also unquestionably soils of such a bright red colour that they could not for a moment be confused with any alluvium. The first six soils in the Statement are of this colour. Bright red colour.

No. 291-94 was a brick-red gravelly soil with the rock very near the surface. Descriptions of Samples.

No. 327-96 is described as a "Red loam; red sandy soil. The plant called in Tamil *Melagapundu*, resembling chillies, is a common weed on this soil. It is said to be intoxicating to cattle."

No. 250-96 is described as "Red sand, called locally *Yerra nela*; needs frequent and copious rainfall for the successful cultivation of crops."

No 333-96 "Red sand; wild indigo grows luxuriantly on the soil. The soil is not far from a hill."

No. 378-96. "Red sand; overlies a bed of gravel at a depth of 2 to 3 feet; is poor; called in Tamil *pottal; Cholum* and *Samai*

(Panicum miliare) are the chief crops; natural herbage scanty; becomes somewhat hard and compact in dry weather, unlike most sandy soils, and in that condition emits a peculiar hollow sound when dug with the *mamooty*. This soil is infested with white-ants, every stalk of the stubble of the last *cholum* crop being covered with ant-hills."

No. 379-96 "Red sand, similar to No. 378, but does not become so hard when dry, nor is it so infested with white-ants, natural herbage good. Considered fit for ground-nuts. *Ragi* does not thrive on this soil.

General Composition.

It will be observed that five of these soils contain higher proportions of iron and alumina than is common to "sandy" soils. The amount of organic matter and nitrogen is also very small, the lime is only very moderate in amount, and the phosphoric acid is distinctly low.

No. 74-96 is described as a "Red loam, locally called *Garuva*. Average depth of soil is 2 feet."

Although this roil contains about as much iron as some of the others of this class, the proportion of alumina is very small. Generally regarding these soils it will be seen that the amount of lime is small or only moderate, the magnesia is not high and the phosphoric acid is uniformly low. On the other hand, the proportion of ferric oxide and alumina is usually high. Indeed their composition is in many respects very similar to the laterite soils (para. 22), the chief feature of dissimilarity being in the respective proportions of phosphoric acid. Whilst the laterite soils contained very varying amounts of this valuable plant food, its proportion in these red soils was very uniform, the extreme variation being between ·05 and ·03 per cent.

STATEMENT No. V.

Composition of Red Soils from Madras Presidency.

DISTRICT	COIMBATORE	MADURA	KURNOOL.	TRICHINOPOLY.			KISTNA.
Taluk.	Coimbatore.	Dindigal.	Pati Konda.	Parambalur.	Trichinopoly.		Guntur.
	291·94	327·96.	250 96	333·96	378 96	379·96.	74·96.
Insoluble silicates and sand	80·33	90·47	68·10	86·74	88·84	85·99	89·31
Iron (Fe_2O_3)	5·18	3·51	6·32	5·70	4·55	7·09	5·90
Alumina (Al_2O_3)	7·50	2·92	15·84	5·68	3·46	3·19	1·57
Manganese (MnO)	·10	·08	·07	·10	·06	·08	·08
Lime (CaO)	1·11	·56	·79	·48	·10	·16	·46
Magnesia (MgO)	·65	·70	·80	·70	·38	·28	·30
Potash (K_2O)	·36	·24	·23	·05	·28	·11	·45
Soda (Na_2O)		·12	·19	·15			
Phosphoric acid (P_2O_5)	·09	·09	·06	·05	·04	·11	·08
Sulphuric acid (SO_3)	Nil.	Nil.	Nil.	Nil	Nil.	Nil.	Nil.
Carbonic acid (CO_2)	·85	·30	·20	11	·03	·08	·10
Organic matter and combined water (difference)	3·83	1·01	7·40	24	2·26	2·91	1·75
TOTAL	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Nitrogen	·021	·006	·051	·021	·001	·005	·012

S. 2260 a.

SOILS. | On the Composition of

LATERITE SOILS.

22. In the accompanying Statement No. VI, are set out the analyses of a number of soils which have been named as "laterite" by the senders.

Origin of laterite uncertain.

When summing up the evidence as to the origin of laterite Mr. Oldham (*Geology of India*, page 385) writes: "From what has gone before it will be seen that the subject of the origin of laterite is still wrapt in obscurity. None of the various hypotheses that have been propounded is completely satisfactory, nor is it possible to come to any final conclusion till an agreement is come to as to the meaning of the word laterite"

If then it is difficult for the Geologist to decide what is "laterite," it becomes practically impossible for the agriculturist to say what is a "laterite soil."

Those "laterite soils," that is, soil lying on or adjacent to what had every appearance of being laterite rock, which I have seen, had all a bright red appearance when dry; but as will be seen when discussing the analyses of the samples which I have examined, some at least *of these are probably not true laterite*.

23. The following are the descriptions of the soils:—

Description of samples

No 218-96 is the surface soil of a field at Saidapet, Madras. The soil consisted of a coarse brick-red gravel. It will be observed that that there is practically no lime, no phosphoric acid, and a very small proportion of nitrogen.

Nos. 280-96 to 283-96.—These four samples, two of surface and two of sub-soil were sent by the Deputy Commissioner of Hazaribagh. When sending them he worte: "I have the honour to submit two samples of laterite soil, or the nearest approach to it, since laterite soil cannot be found in this district."

All the samples were, however, of a bright red soil. They contain comparatively much manganese, and more lime than any of the other laterite soils examined, though for agricultural soils they are not by any means too well off in this particular. The amount of phosphoric acid is very low, being less than $\frac{1}{100}$ per cent. in three of them. The proportion of nitrogen, though higher than in some of the other laterite soils, is, *nevertheless*, low from the agricultural point of view.

Nos. 284 and 285-96.—These two, a surface and a sub-soil, were received from the Deputy Commissioner of Lohardaga and were selected by the District Engineer, who wrote: "The accompanying specimens, I believe, are of the laterite soil of this district or a fair representative of it. As far as I have seen, the soil is not a compact mass, but loose and gravelly, that is a mixture of pebbles of various sizes and dust; sometimes there are compact blocks mixed with the gravel; a specimen of a block is herewith submitted. As a rule these pebbles appear to be partially fused and at places there are fragments of quartz and (rarely) other rocks mixed with them. Three specimens are sent herewith.—*1st*, surface soil taken within 12 inches depth (No. 284-96); *2nd*, sub-soil 12 to 24 inches in depth (No. 285-96); *3rd*, a compact block found mixed with the loose soil (not analysed)."

The reference to the pebbles appearing partially fused is an indication that this is a true laterite gravel, the "fused" appearance being due to a crust of limonite in them. The analyses indicate that both the surface and sub-soil are so rich in iron that they might with more propriety almost be called iron ores.

The amount of alumina, though higher than in the alluvial soils of India, is not more than in the other *laterite* soils here referred to.

The proportions of lime and magnesia are low, so also is the nitrogen. The loss on heating is naturally high, owing to the high proportion of hydrated peroxide of iron. The phosphoric acid is quite unusually high in comparison with other Indian soils.

No. 358-96 is a surface soil sent by the Deputy Commissioner of Singbhum and described as laterite. It also contained a very high proportion of iron and is doubtless of lateritic origin. The sub-soil which was pink, had the general appearance of laterite. This soil also contains very little lime and magnesia, and the amount of phosphoric acid is as small as in many other Indian soils.

Nos. 360-96 to 367-96 were eight samples of soil, four surface and four sub-soil, sent by the Deputy Commissioner of Manbhum District, Chota Nagpur. Only the surface soils were analysed.

Nos. 360 and 361 are described as "*Purulia*" *land* (high land), the former being the surface 8 inches, the latter the sub-soil. It is of a "sandy and gravelly nature." The surface soil, analysis of which is given, consisted of a soft *drab* soil, more like alluvium than anything

else; the "sub-soil" simply consisted of pieces of quartz with ferruginous veins here and there, and had no similarity to the laterite which I have seen at Madras and the Deccan. The composition of the surface soil is merely such as one would expect any alluvium to have and is devoid of striking peculiarities.

Nos. 362 and 363 are the surface 9 inches, and sub-soil of what is described as *Bengabara tand* (high land). "The land is of a sandy and gravelly nature." The surface soil 9 inches, No. 362, was similar in appearance and colour to No. 360. Its composition is similar to No. 360 in most respects, but the proportion of phosphoric acid is higher and it contains more nitrogen. The sub-soil (not analysed) was a grey lumpy earth with some little pieces of rock intermixed.

Nos 364 and 365 are described as "*Simalia tand* (high land)." "The land is a sandy and gravelly high land almost free from grass and other weeds" No. 364, the surface 9 inches, was a brown soil; the sub-soil No. 365 was apparently laterite rock.

Nos. 366 and 367 are the surface 12" and the sub-soil of what is described as *Raghunathpur* (high land) "a mixture of mud, sand and gravel." The surface soil was similar to No. 364 in appearance, and the sub-soil consisted of laterite rock.

These four surface soils are in most respects similar to one another in composition, and excepting that Nos. 360 and 362 were more of a drab colour, whilst 364 and 366 were of a deeper brown, they were similar in appearence.

There is, moreover, nothing in their appearance or composition which is similar to the other "laterite" soils here described, and had it not been for the fact that laterite rock underlies two of them near the surface I should have assumed that they had no connection with laterite at all. Under the circumstances all that one can do is to point out the dissimilarity.

General composition.

The other eight samples are probably true representatives of the laterite soils, and the somewhat wide variations in their composition, especially in the proportion of iron, illustrates a feature that one might have predicted, for a rock which itself contains hydrated peroxide of iron (if indeed it does not actually owe its origin to the presence or formation of this substance) might naturally be expected to lose larger or smaller amounts of it during its decay, the less soluble silicates being left behind. As will be

seen, the amount of ferric oxide varies from 4 up to as much as 48 per cent. The amount of manganese appears to be sometimes higher than in soils generally; lime is in no case abundant, and generally it is deficient. The amount of phosphoric acid varies greatly. In two of the eight samples it is unusually high for Indian soils, but in four it is *very* deficient, and in the others the amount is lower than one might wish. Lastly, there is in no sample any large amount of organic matter or nitrogen, though in some of the samples the latter is present to the same extent as it is in *regur*.

SOILS.

On the Composition of

STATEMENT No. VI

Analyses of Laterite Soils.

	SAIDAPET, MADRAS.	HAZARIBAGH DISTRICT, BENGAL.		HAZARIBAGH DISTRICT, BENGAL.		LOHARDAGA DISTRICT, BENGAL.		SINGHBHUM DISTRICT, CHOTA NAGPUR.	MANBHUM DISTRICT, CHOTA NAGPUR.			
		Surface soil.	Sub-soil	Surface soil.	Sub-soil.	Surface soil.	Sub-soil.	Surface soil.	Surface soil.	Surface soil.	Surface soil.	Surface soil.
	218-96.	280-96.	281-96.	282-96.	283-96.	284-96.	285-96.	358-96.	360-96.	362-96.	364-96.	366-96.
Insoluble silicates and sand	76·86	78·62	74·84	80·46	76·96	29·67	33·66	59·06	90·07	85·50	90·29	90·34
Iron (Fe_2O_3)	10·09	6·35	6·96	6·12	6·40	48·71	42·08	26·64	4·27	5·68	2·90	3·17
Alumina (Al_2O_3)	8·84	8·98	11·57	7·19	11·31	8·81	13·89	7·27	2·59	4·00	4·49	2·95
Manganese (Mn O)	·19	·39	·28	·50	·33	·07	06	·48	09	·11	09	·06
Lime (Ca O)	Trace	1·50	·96	1·72	·94	·38	45	28	·14	·47	·14	·38
Magnesia (Mg O)	·77	·66	·81	·38	·51	·21	20	·33	·31	·60	·28	·36
Potash (K_2O)	·09	·43	} ·70	·38	} ·44	·10	} 27					
Soda (Na_2O)	·17	·21		·32		·04		·27	·14	·40	·19	·25
Phosphoric acid (P_2O_5)	Trace	Trace	Trace	Trace	04	·64	26	·08	·13	·30	04	·06
Sulphuric acid (SO_3)	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Carbonic acid (CO_2)	·12	·12	·08	·12	·05	·06	·12	·16	·28	·06	·05	·38
Organic matter and combined water (difference)	2·87	2·74	3·80	2·81	3·02	11·31	9·01	5·43	1·98	2·88	1·53	2·05
TOTAL	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Nitrogen	·015	·039	·032	·030	·026	·010	·010	·024	·016	·032	·031	·036

COFFEE SOILS

24 The accompanying Statement No. VII exhibits the composition of some soils from a coffee estate in the Sheveroys, Madras, which Mr. C. G Lechler very kindly sent me from his Brooklyn Estate It will be observed that one is of newly broken up jungle land, one from land which had borne coffee for two years, two of land which had been under coffee for twelve years, and two which had borne the crop for forty years Source.

In physical appearance these soils were all similar, consisting of a nice open soil with a good admixture of organic matter. And, as might be expected, they are, in general composition, alike. The amount of iron and alumina, especially the latter, is unusually high (they are in no sense clays), the amount of lime very low, alkalis only in moderate amount. Appearance.

In the matter of the important plant foods, organic matter and nitrogen, and phosphoric acid they are well supplied. Moreover, comparing the soils, which had been many years under coffee, with the newly broken jungle land, it will be seen that the soil has not suffered any very serious loss by the process. They all contain somewhat less phosphoric acid and a little less nitrogen (in two cases a good deal less) than the newly broken up jungle, but excepting in the case of No. 372, which contained only ·05 per cent phosphoric acid, the differences are not great, especially when it is remembered that the samples are not from one small area, but from different parts of the estate, and one cannot of course assume that the land was in each case precisely like No. 371. Doubtless the fertility of the land has been maintained by the careful and constant manuring which the coffee planters provide Composition.

STATEMENT No. X.

Composition of other Tea Garden Soils.

	(12) Teela Soil from North Cachar had been under tea for several years	(14) Teela Soil, Central Cachar, had been under tea for several years.	(19) Darjeeling, Kurseong District.
Organic matter and combined water	2 66	3·78	11·28
Sand and silicates	92 17	89 63	70 33
Soluble silica	·01	·12	...
Lime	trace	·06	·25
Magnesia	·04	·23	trace
Potash	·20	·21	2·50
Soda	...	...	.
Manganese	·06	...	·13
Oxide of Iron	2 09	3·26	5·97
Alumina	2 73	2·37	9·27
Phosphoric acid	04	20	·27
Sulphuric acid	trace	trace	...
TOTAL	100·00	99·86	100·00
Nitrogen equal to Ammonia	·062	·124	·535

No. 14. "A soil from Central Cachar, very finely divided ferruginous sandy soil from an old *teela* which had been under tea for several years and was similar in character to No. 12."

No. 19. "A soil from the Kurseong District, dark in colour very hygroscopic, containing much potash-mica, and fragments of easily disintegrating micaceous rock"

Description of *Bhil* and *Teela* soils.

28. It would appear that the soils of the Tea-Gardens vary very much in composition and character, as might well be expected from the fact of their position being either in the hills or in their immediate neighbourhood. The two extreme variations are represented by the *bhil* and *teela* soils. The former are, especially when first opened out, peaty, and consequently consist largely of organic debris with high proportions of nitrogen. The latter (*teelas*) are sandy. Speaking of the former Mr. Bamber says :— "Peaty soils, such as are found in Cachar and Sylhet, but more rarely in Assam, have a marvellous power of causing tea to yield rapid and heavy flushes, but such tea is not of very good quality and has little or no flavour. But after they have been opened out, drained

Bhil soils

and cultivated for two or three years, the quality of the tea gradually improves without the quantity decreasing to any extent. When first opened out, these soils are very rank and sour in character, due to the want of proper oxidation by the air, which has been prevented by the dense undergrowth of the jungle excluding the air, and to the presence of an excess of stagnant water in the soil itself. By the burning of the jungle, when cut, a large quantity of mineral matter is given to the soil in the form of carbonates, which assist in neutralising the acid humic matters contained therein, and rendering the soil fit for the growth of cultivated plants. This change is also assisted by the cutting of deep drains to remove all stagnant water containing effete and poisonous matters in solution.

Sour at first.

Improvement

The depth of *bhil* soils varies from 2 feet to 10 feet or more, and usually below them there is a dense sub-soil of blue clay, the colour being due partly to certain organic substances, and partly to the presence of the lower oxides of iron, which are distinctly poisonous to plants. When the soil is not very deep and the roots of the tea are likely to penetrate to a sub-soil of the above description, it would be necessary first to dig drains of some depth into the sub-soil, and so cause aeration and oxidation of the iron compounds, otherwise when the roots of the plants descended, they would absorb these poisonous constituents, which would either check their growth or kill the plants entirely

Depth.

Drainage.

Peaty *bhil* soils undergo a great change and loss when under cultivation, due to the combined action of the air and rain on the organic matter, which is rapidly oxidised to carbonic acid, and either washed away or given into the atmosphere as gas. Owing to this rapid and serious loss of organic matter and nitrogen, it is necessary to adopt some means of lessening it as much as possible, and this would be best done by limiting the amount of cultivation or hoeing given throughout the year. It must be remembered that these soils are already very light and porous, and when well drained admit air freely into their interior, so that cultivation is not so necessary as when the soil is more compact, and need only be done to bury the jungle when it attains a size, that would interfere with the growth of the bushes. By adopting such a system, the amount of organic

Changed by cultivation.

matter decomposed would be almost, if not quite, replaced by that obtained from the atmosphere by the buried jungle, and deterioration of the soil would be largely prevented. The well-known luxuriant growth of tea or other plants on such soils is due in a great extent to the rapid decomposition of the organic matter, which affords an abundant supply of carbonic acid for the use of the growing plant." . . . "Some *bhil* soils which have been opened out and planted with tea are very heavy in character, being composed almost entirely of a stiff blue clay, which at first has a most unpromising appearance; however when deeply drained at close intervals and thoroughly cultivated for a year, the character of the surface soil undergoes a change in appearance and becomes more gritty and sandy, from the removal of a part of the almost impalpable matter in the soil. This alteration in character proceeds gradually deeper into the sub-soil as the drains become more active, until at last the blue colour almost entirely disappears, having changed to a pale and gradually deepening yellow.

Some *bhil* soils are clayey.

When this change has taken place, the soil appears to grow tea luxuriantly, and such a soil will probably prove far more lasting than the peaty *bheel* soils mentioned above, owing to its retentive character for the bases liberated by cultivation and exposure of the soil to the atmosphere.

Drainage water acid.

Value of lime.

The drainage water from most newly opened *bhils* contains much oxide of iron, which is present in the soil in the form of the lower oxide, and which is gradually deposited after exposure to the atmosphere as the higher or red oxide. It is also invariably very acid, owing to the presence of several organic acids in solution, which are very detrimental to the healthy growth of tea, and should be removed by drainage, or *neutralised by lime, prior to any bushes* being planted out.

If this precaution is not taken, it frequently happens that, although the plants live, their growth is checked for some months until the necessary changes have taken place, and it will be found that such plants will never flush or grow as luxuriantly as those which are planted after the soil has been sweetened by drainage and cultivation."

29. An application of *bhil* soil as manure to lighter soils, such as the *teelas*, has proved very beneficial. For instance, speaking of the soil No. 15 (*vide* Statement No. IX.), Mr. Bamber says :—"When dry this soil is richer in plant food than the cattle manure obtained in this country, and its application as a top-dressing it has proved very beneficial to tea bushes on worn-out *teela* soils."

30. Describing the *teela* soils, Mr. Bamber says :—"Another Class of soils on which tea is largely grown, are the light *teela* soils on which tea was first planted when introduced into Cachar.

Some of these soils when first cleared must have been fairly rich and strong, from the appearance of the jungle and trees growing on uncleared *teelas* at the present time, but they have in almost every case rapidly deteriorated, more from the action of the rain removed by wash and heavy rainfall than from what has been removed by the tea itself.

When protected from direct rainfall by the jungle growth, they gradually increased in richness and value in the same way as other forest soils, but after the jungle was cleared away and the surface soil loosened by cultivation, they were washed down from the summit and slopes of the *teelas*, and helped to form and enrich the *bhil* soils beneath.

Attempts have been made with a certain amount of success to prevent this wash by terracing the slopes of the hills, but in many cases this was only done, when the best of the soil had been washed away, and the effects were not so beneficial as they would have been had the terraces been made when the *teelas* were first cleared. The character of these *teela* soils does not vary much, being generally a light sandy loam, formed from the decomposition of the laterite rock beneath, but occasionally the soil rests upon a pebbly sub-soil, which fact, together with the sharp slopes, makes drainage too excessive, so that the bushes are very liable to suffer from drought, in any but a very wet season.

In a few instances the base of the *teelas* is formed of a dense whitish clay, which yield a soil very unsuitable for the successful growth of tea, but the outcrop of such a soil is usually very small in extent, and beyond its effect on the drainage of the *teelas* in which it occurs, its presence is of little importance."

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Chemical composition. 31. Regarding the composition of the tea garden soils generally, it will be observed that they are much better supplied with the plant foods, phosphoric acid and nitrogen, than are any of the other classes of Indian soils which I have examined, excepting in the case of the Coffee soils from the Sheveroys.

Nitrogen. *Phosphoric acid.* The soils of the Dooars, as represented by the analyses quoted in Statement No. VIII., contain from ·1 to ·35 per cent. of nitrogen; the proportion of phosphoric acid is somewhat low in certain of them and varies from ·05 to ·17 per cent. But the *bheel* soils all contain much higher proportions of these plant foods. The *teela* soils seem to vary a good deal. The soil No. 12 is undoubtedly poor, but the other one of this class No. 14 contains a very ample supply of both phosphoric acid and nitrogen.

Potash. The supply of potash in these tea garden soils appears to be ample, as indeed I have found generally in Indian soils.

Lime. 32 The particular ingredient which seems to be most deficient in the Assam soils generally is lime. Mr. Bamber remarked on this and set out in a separate statement (No. XI. of this paper) the proportions of lime found in all the soils which he examined. From this statement it will be seen how very small is the amount of lime throughout.

STATEMENT No. XI.

Proportion of Lime in Tea Garden Soils.

	Assam	Cachar.	Kangra.	Darjeeling	Dooars.	Chota Nagpur.
1	trace.	trace.	·38	·48	·14	·01
2	,,	,,	·39	·15	·30	...
3	,,	,,	·06	...	...	...
4	,,	,,	·17	...	...	...
5	,,	·19	·12	...	...	...
6	·10	·11	·58	...	...	...
7	·15	·12	..	...	...	...
8	·31	·05	...	...	...	...
Average per cent. of Lime . .	·07	·06	·29	·32	·22	·01

In Appendix 44 of Mr. Bamber's book the cost of *burnt* lime is estimated at R112 to R128 per 100 maunds, with an additional R15 to R30 for carriage, to which has to be added the cost of the earthen jars in which it is packed. One hunded maunds per acre

would be equivalent to about 0·2 per cent of lime in the first foot of soil, and this would cost about R 150. To bring about a radical change in soils which contain so little lime it is probable that 200 maunds would have to be applied so as to raise the percentage to about 0·5. But it is also probable that *unburnt* limestone, ground up so as to pass through ¼ inch sieve, would produce the desired effect, and the cost of this might be considerably less than the above. Another point which I do not see noticed in Mr. Bamber's book is the question whether one could not effect a remedy without the aid of lime, by burning some of the soil near gardens which require lime, or at least a free alkali. The part which the lime would play in such soils as those under notice, would be to keep the land "sweet," *i.e.*, prevent it from becoming sour. In England the process known as "pearing and burning" is employed. The surface soil is collected in heaps, mixed with fuel and burnt. The combustion is "slow" and the temperature is not allowed to rise sufficiently to burn the clay to brick, but merely high enough to liberate some of the alkalis and alkaline earths. It seems possible that this might be done in the neighbourhood of gardens, and the burnt earth applied to take the place of lime.

Cost of liming.

Pearing and Burning.

THE POONA (MANJRI) FARM SOIL.

33. Samples of the soil of the field at Manjri (Poona) which is devoted to sugarcane, were taken prior to the commencement of the experiments in 1894, and the proportions of nitrogen, phosphoric acid and potash determined in them. The accompanying Statement No. XII sets out the results of those analyses.

STATEMENT No. XII.

Analyses of Soils from Manjri, Poona.

	Plots 2 and 3	Plots 5 and 6	Plots 8 and 9.	Plots 13 and 14	Plot 22.
	Per cent.	Per cent	Per cent.	Per cent.	Per cent.
Total Nitrogen	·014	·034	·031	·024	·035
Total Phosphoric acid	·031	·025	·014	·022	·016
Available Phosphoric acid	·010	·010	·005	·008	·010
Available Potash	·008	·008	·005	·009	·016

Composition.

The proportions of nitrogen and phosphoric acid (total) are low. The amounts of available phosphoric acid and potash are probably sufficient for ordinary crops, but they are not high; about one-third of the total phosphoric acid is readily "available."

THE NAGPUR FARM SOILS.

34. Samples from three plots at this farm were selected in 1896, and the amounts of the principal plant foods determined in them.

These are set out in Statement No XIII.

Composition.

The proportion of nitrogen is slightly higher than that in most *regur* soils; that of *total* phosphoric acid is about average.

The proportion of *available* phosphoric acid varies. In the surface soil of Plot A-4, which has been regularly manured, there is a very fair amount, but in the surface soil of Plots A-8 and A-7 there is very much less. Plot A-8 has been regularly manured by ploughing in a green crop, but it must be recollected that this system of manuring adds no phosphoric acid to the soil, though one might have anticipated that this procedure would have occasioned an accumulation of *available* phosphoric acid. Plot A-7 has remained unmanured, and the low proportion of *available* phosphoric acid is readily understood. The amount of *available* phosphoric acid in the sub-soil of all the plots is low.

The percentage of available potash is fair in all the samples.

STATEMENT No. XIII.

Analyses of Soil from the Nagpur Experimental Farm.

	PLOT A-4 MANURED WITH 6 TONS OF CATTLE *MANURE PER* ACRE PER ANNUM		PLOT A-8. MANURED WITH GREEN HEMP *PLOUGHED IN* ANNUALLY.		PLOT A-7 UNMANURED.	
	Surface soil	Sub soil	Surface soil.	Sub-soil.	Surface soil.	Sub-soil.
	Per cent	Per cent	Per cent	Per cent	Per cent.	Per cent.
Total Nitrogen .	·065	·033	·045	·033	·050	·047
Total Phosphoric acid	·093	·065	·075	·058	·064	·054
Available Phosphoric acid	·022	·008	·008	·004	·007	·005
Available Potash .	·021	·010	·016	·010	·012	·010

THE CAWNPUR FARM SOIL.

35 A number of samples of the surface soil of certain of the experimental plots at Cawnpur have been analysed. Statement No. XIV. sets out the results.

Effect of manuring.

The effect of the manures has been to materially raise the proportion of nitrogen. The proportion of phosphoric acid has not been generally increased. Of the total phosphoric acid from $\frac{1}{3}$ to $\frac{1}{5}$ is available, excepting in the case of the two plots which have been regularly manured with Indigo "Seet."

The proportion of available potash is fairly high in most cases.

THE DUMRAON FARM SOIL.

36. When the new land at Dumraon was taken up in 1895, samples of the surface soil and sub-soil were taken from eight spots, four in the Northern half and four in the Southern half, and the amounts of the principal plant foods determined in each.

A complete analysis of the mixed surface soil samples, and one of the mixed sub-soil samples, was also made.

The following Statement No. XV. sets out the results.

Land uniform.

The quality of the land was remarkably uniform, and coincides generally with soils of the Gangetic alluvium. Of the total phosphoric acid, about $\frac{1}{4}$ was *available* in the surface soil, but in the subsoil the proportion available was considerably less than this.

SOILS. On the Composition of

STATEMENT No. XIV.

Analyses of the Soil of the Cawnpur Experimental Farm.

	Total Nitrogen.	Total Phosphoric Acid.	Available Phosphoric Acid.	Available Potash.
	Per cent.	Per cent.	Per cent.	Per cent.
Unmanured Plots.				
Rabi Standard No. 11	·024	085	·021	·012
Kharif Standard No. 13	·016	053	·022	·007
Alternate Series A No. 13	·017	·088	·030	·007
Ditto B No. 11	023	·071	·014	·012
Green Manure Series No. 5	·017	·052	·015	·027
Manured Plots.				
Rabi Standard No. 3 (Each manured annually with 180 maunds or 14,400 lbs. of cattle dung per acre.)	031	·067	·032	·012
Kharif Standard No. 3 (Each manured annually with 180 maunds or 14,400 lbs. of cattle dung per acre.)	·065	·094	·047	·027
Alternate Series A No. 6 (Each manured annually with 180 maunds or 14,400 lbs. of cattle dung per acre.)	·024	·072	·036	·012
Ditto B No. 3 (Each manured annually with 180 maunds or 14,400 lbs. of cattle dung per acre.)	·042	·072	025	·019
Green Manure Series No. 2 (Manured annually with 120 maunds or 9,600 lbs per acre of fresh Indigo seet)	·038	·089	009	·011
Green Manure Series No. 1 (Manured annually with 120 maunds or 9,600 lbs. per acre of old Indigo seet.)	·107	·079	·008	·007

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STATEMENT NO. XV.

Analyses of the Dumraon (new) Farm.

	Surface soil 1″-9″				Sub-Soil 9″-2′ 9″.			
	Nitrogen.	Total Phosphoric Acid	Available Phosphoric Acid.	Available Potash	Total Nitrogen	Total Phosphoric Acid	Available Phosphoric Acid.	Available Potash
	Per cent.	Per cent.	Per cent	Per cent.	Per cent.	Per cent	Per cent	Per cent
North half of Farm—								
North	·043	·069	·015	·013	·043	·076	·008	·006
South	·047	·066	·009	·009	·049	·071	·005	·010
East	·042	·063	·012	·010	·037	·074	·005	·008
West	·047	·099	·023	·013	·039	·084	·006	·009
South half of Farm—								
North	·041	·081	·012	·009	·041	·065	·003	·007
South	·043	·083	·021	·010	·039	·124	·010	·009
East	·042	·077	·015	·012	·039	·067	·004	·007
West	·049	·089	·017	·015	·039	·071	·006	·010

	Surface soil.	Sub-soil
Insoluble silicates and sand	86·73	80·78
Soluble silica	·09	·12
Iron (Fe_2O_3)	4·09	6·12
Alumina (Al_2O_3)	4·57	6·50
Manganese (MnO)	·10	·14
Lime (CaO)	·30	2·07
Magnesia (MgO)	·76	1·17
Alkalis (K_2O Na_2O)	·48	·73
Sulphuric acid (SO_3)	.	...
Phosphoric acid (P_2O_5)	·08	·08
Carbonic acid (CO_2)	1·07	} 2·29
Organic matter and combined water	1·73	
TOTAL	100·00	100·00
Nitrogen	·049	·041

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GENERAL CONCLUSIONS REGARDING THE COMPOSITION OF INDIAN SOILS.

37. Having now examined individually the composition of the several different classes of soil, it will be well to summarise the deductions which may be drawn from the information thus supplied and at the same time compare them with the opinion of Indian soils at which Dr. Voelcker arrived from an examination of such few analyses as were at his disposal when writing his report.

Silicates.—The proportion of silica and silicates was determined by digesting the soil (after gentle ignition) in concentrated hydrochloric acid, and it may be here remarked that they were in all cases (even those of the *regur* soils) quite white after this treatment.

Alluvial Soils. *Regur.* Red Soils. Laterite. Madras alluvium. Coffee Soils. Assam Soils.

In the soils of the great Alluvial Plains, their amount is much about the same as one is accustomed to find in English loams and clays. In the Black cotton soil (*regur*) their amount is uniformly low; due principally to the high proportions of ferric oxide and alumina and the water combined with them, and to a lesser degree to the presence of larger amounts of lime and magnesia than many English loams contain. In the Red Soils of Madras the proportion of silicates is low in two cases, due to the presence of large amounts of iron and alumina; the other samples contain high amounts. The laterite soils yielded very varying amounts of insoluble silicates, which was due almost entirely to the great variations in the amount of iron and alumina which is a chief characteristic of these soils. In the Brown Alluvial soils from Madras Presidency, the proportion of silicates is low in the loams, chiefly owing to the high proportions of iron and alumina which these soils contain. In the Coffee soils from the Sheveroys the silicates are very small in amount, due in part to high proportions of iron and alumina, but in part also to high proportions of organic matter. In the Assam soils, the proportion varies very much, according to the proportion of organic matter present.

Iron usually high.

Iron.—The amount of Iron which exists in Indian soils appears to be in all the classes examined higher than what one is accustomed to meet with in English soils. In the soil of the Indo-Gangetic alluvium it occurs in proportions varying from 2 up to 7 per cent. In the *regur* its proportion varied from 4 up to 11·5 per cent. In the Madras red soils it varied from 3·5 to 10 per cent.; in the 8 laterite soils (the

identity of which could not be doubted) from 6 up to 48 per cent., but in the four doubtful laterites it fell to a much lower figure. In six of the Madras alluviums the proportion was from 5 up to 17 per cent. In the Assam soils the proportion varied very much, but was generally *high*. *Lastly the coffee soils contained from 9 to 12 per cent.* Thus there can be little doubt that the amount of iron in Indian soils is large, in some very large indeed.

Alumina.—In the case of the alumina, too, almost all the soils examined contained *high proportions* *In the soils of the great alluvium*, it varied from 3 up to nearly 10 per cent.; in the *regur* from 6 up to nearly 14 per cent.; in the red soils there was a good deal of variation, the extreme limits being 1·5 and 15·8 per cent.; in the *first eight of the laterite soils it varied from 7 up to nearly 14 per cent.*, though the four doubtful laterite soils contained much less; in the Madras alluvium it varied from 6 up to 15 per cent. in the loams, but there was much less in the sandy soils. Lastly the Coffee soils contained the very high proportion of 17 to 20 per cent. Usually high proportion.

Manganese.—This metal appears to be very widely distributed in the soils of India, though it occurs only in small amount, the proportion in the alluvial soils varied from ·11 to 30, in the *regur* from ·1 to 26; in the red soils from ·07 to ·20; in the laterite soils from ·06 to ·50; in the Madras alluviums from ·03 to ·26 per cent, whilst the coffee soils contained from ·07 to ·09 per cent. Widely distributed.

Lime.—The proportion of Lime in the soils has been calculated to the oxide for the sake of uniformity. Some of the lime in all the soils exists as carbonate, some part as silicate. As is well known calcareous soils are generally absent from India, the only one of those examined that could fall under this category being the soil from Captain Chapman's estate; the peculiar circumstances under which this soil has been forming have been already alluded to. The soils of the alluvium contained from ·3 to 2 per cent.; the *regur* soils contained more, namely, from 1·0 to 7·7, the greater number of them contained from 2 to 5 per cent.; the red soils, the laterites and the Madras alluvium contained uniformly small proportions, usually less than 1 per cent., the coffee soils had about ·3 per cent., and many of the Assam soils even less than this. Dr. Voelcker writes: "speaking generally, lime is more plentifully distributed in Indian soils than Calcareous Soils rare. Alluvium. *Regur.* *Laterite.*

in English; that is, deficiencies are not so frequently met with. A notable exception, however, which I have found is in the laterite soil of parts of Southern India such as the coffee-growing districts of Coorg and Mysore, and the Tea Plantations in the Nilgiris, where, I have reason to believe, a more abundant supply of lime would be decidedly beneficial." The evidence now afforded by the analyses quoted substantiates this opinion *in the main*. There is undoubtedly sufficient lime in the *regur* soils, and most of the soils of the Gangetic alluvium contained a sufficiency; of the laterites 7 out of 12 also contained a sufficiency, and it was deficient in none of the Madras red soils. These remarks as to sufficiency and deficiency, however, are really based on a European standard, and it must be considered an open question whether it is proper to apply such a standard to Indian soils. One of the chief objects which an English farmer has in maintaining a fair proportion of lime (1 per cent. at least) in his land is the retention of a sufficient amount of free basic matter to combine with the organic acids which are constantly formed from the humus. The proportion of humus in English soils is unquestionably higher, much higher than is the case with Indian soils, and consequently it is open to doubt whether Indian soils usually are in absolute need of so large an amount of lime as one would consider necessary for English soils. Thus I feel certain that the laterite soils, for instance, which contain so little lime, would not be benefited materially by an application of it. On the other hand, the coffee soils from the Sheveroys are somewhat differently placed. The *total* amount of lime present in them is not *very* small, but still it is not large and most of this exists as silicate. These soils contain also a very considerably greater proportion of humus than other soils from the plains, and it *may* be that such land as this would be benefited by an application of lime. The Assam Tea garden soils would, I feel certain, be very greatly benefited by an application of this substance.

Usually sufficient.

European standard considered in relation to Indian Soils.

Magnesia.—Dr. Voelcker's remark that "Magnesia appears to exist in sufficient abundance throughout, and more plentifully than in English soils" (paragraph 64) is amply confirmed. In the soils of the Gangetic alluvium it seems to be generally present in amount exceeding 1 per cent. The *regur* soils contained even more than

Generally Plentiful.

this, in two samples only did the proportion fall appreciably below 2 per cent., and in one case it ran up to 3 per cent., indeed in these soils its amount is singularly uniform, nearly all the samples containing from 2 to 2½ per cent. The red soils contained usually about ¾ per cent. There appears to be less of this element in the laterite soils than in the other classes referred to.

Potash.—The proportion of Potash appears to be ample in all classes of soils

Ample Potash

38. *Phosphoric acid*.—From the few analyses which Dr. Voelcker had at his disposal he concluded that phosphoric acid is "more abundantly distributed in Indian than in English soils," and he suggests that ·12 or ·13 per cent. would be a good average for English soils. Of the ten analyses which Dr. Voelcker had at his disposal, five contained more than this amount and five a little less than this. The lowest was ·09 per cent. Among the samples which I have examined, the majority contained considerably less than Dr. Voelcker's standard. Of the Gangetic alluvial soils, six contained ·08 or less, four contained from ·09 to ·13, and only two, namely, the Changa Manga soil and the calcareous one, both of which had been placed for long periods under influences of accumulation of plant food contained more than ·13 per cent. Of the eighteen *regur* soils, sixteen contained ·08 or less of this plant food, the other two containing about ·20 per cent Of the six red soils, four contained ·08 per cent. or less, the remaining two ·09 per cent. Of the laterite soils, four contained less than ·01 per cent. four others ·08 per cent. or less, and four others fair amounts. The Madras alluvial soils contained, as a whole, somewhat more, there being ·08 per cent. or more in six out of ten samples, but the other four contained only very small amounts. The coffee soils have doubtless been well manured, and contained with one exception ·1 per cent. or more. The Assam soils appear to be far better off in respect of phosphoric acid than any other soils in India. In none of those examined could there be said to be a serious deficiency.

My samples usually contained less Phosphoric acid than Dr. Voelcker's

Thus as regards the amount of phosphoric acid, it is obvious that most of the soils of India are not abundantly supplied, but rather it must be admitted that the amount is frequently small. Glancing, too, at the analysis of the farm soils, it will be seen that the land at Manjri

Usually low proportion.

(Poona) contained, when first taken up for the sugar-cane experiments, ·03 per cent. or less of total phosphoric acid (paragraph 32), and the soil of the (new) Dumraon Farm about ·08 per cent. when first taken up (paragraph 35). On the other hand, exceptions to the general conclusion as to the usually low proportion of phosphoric acid in Indian soils, are found in the case of the Assam soils and those of the Meerut District. The soils from the Meerut District contained (*vide* paragraph 45), very distinctly larger amounts of this plant food. Some of them contained as much as ½ per cent., eighteen out of the thirty-five contained ·1 per cent, or over, and only two contained less than ·06 per cent.

39. *Available Phosphoric acid.*— Although the knowledge of the total amount of phosphoric acid in a soil acts as a guide to one in forming an opinion as to the desirability or otherwise of supplying phosphates to land, still it has long been recognised that a more accurate means of judging this point would be most valuable.

Dr. Dyer's investigations.

In 1894, Dr. Bernard Dyer, of London, published an important paper before the Chemical Society, in which he showed that a close relation existed between the amount of phosphoric acid which was dissolved by citric acid, and the known fertility of certain plots at the Rothamsted Experimental Station.

Method.

An examination of a large number of the roots of plants showed that the acidity of the sap was on the average equivalent to very nearly 1 per cent. of citric acid, and Dr. Dyer then submitted certain of the Rothamsted soils to the action of a 1 per cent. solution of citric acid for seven days. He took as his standard soil, the surface soil of the field in which barley had at the time been grown continuously for 40 years. The Rothamsted experiments have yielded such uniform results that the relative agricultural fertility of the several plots was well known.

The treatment of the soil for seven days with citric acid was admittedly empirical, but what Dr. Dyer aimed at was to demonstrate whether the result of such treatment would correspond at all with the known fertility of these standard soils.

The result of this research showed conclusively that a very close correspondence existed between the amount of phosphate

thus dissolved from these soils, and their known fertility in the matter of phosphates.

A second part of the investigation consisted in answering the same question in relation to potash, and in this case likewise a close relation was made apparent between the amount of potash soluble in 1 per cent. citric acid solution, and the known requirements of the land for this plant food.

Meaning of *available* Phosphoric acid.

The potash and phosphoric acid in soils which is thus dissolved by citric acid is styled the "available" potash or phosphoric acid. Dr Dyer examined twenty-two soils in this manner, and he concluded from his research that "when a soil is found to contain as little as about ·01 per cent, of phosphoric acid soluble in a 1 per cent. solution of citric acid, it would be justifiable to assume that it stands in immediate need of phosphatic manure."

Only certain of my samples tested

Although for want of time, the amounts of phosphoric acid and potash rendered soluble by 1 per cent solution of citric acid have not been determined in all the samples of soils which were considered typical of Indian agricultural land, the determination of the total and available phosphoric acid was carried out on some of the farm soils and in the case of the soils of the Meerut district. We have thus five sets of determinations of this "available" phosphoric acid, two in *regur* soil (Manjri and Nagpur), and three in the alluvium, (namely, Meerut, Cawnpur and Dumraon), and although these cannot be considered to be so fairly representative of Indian soils as those in Statements Nos. I. to XI., still it would seem that a conclusion may be drawn from them indirectly as to the amount of "available" phosphoric acid in certain classes of Indian soils.

The amount of total phosphoric acid has been shown to be low in most Indian soils as judged by a European standard. The further question now presents itself, "How much of the phosphates in Indian soils is available?"

Bearing in mind the standard which Dr. Dyer has proposed, namely, ·01 per cent. of "available" phosphoric acid, we may glance at the analyses of the Meerut and other soils in which both the *available* and *total* phosphoric acid have been determined.

Meerut Soil

Of the thirty-five soils from the Meerut district only two fell below the standard. Of the samples from the field at Manjri (when taken up

SOILS.	On the Composition of

Manjri, Cawnpur.

in 1894), only one contained appreciably less than ·01 per cent.; of the samples from the Cawnpur Farm, none of those from plots which had remained for 15 years without manure contained so little as the ·01 per cent. limit, and most of them a good deal more; and

Dumraons.

of the soils from the Dumraon Farm when taken up in 1895, only one contained less than the standard (namely, ·009 per cent.).

Most of the Meerut soils doubtless contain much more than an average amount of phosphoric acid, and may, for the moment, be set aside. The Manjri soils contained no large amount of total phosphoric acid (only ·015 to ·03), indeed very decidedly less than what *regur* soils have been shown to generally contain. The soil of the new Farm at Dumraon contained about ·06 to ·08 per cent. total phosphoric acid, which is much about the same as the soils of the alluvium have been shown to contain generally; and the soils from the unmanured plots at Cawnpur, containing from ·05 to ·08 per cent. total phosphoric acid, have also much about an average allowance. Thus it is seen that, although the only soils in which the *available* phosphoric acid has been determined are from but a few places, the farm soils are not exceptionally rich in *total* phosphoric acid. Whilst therefore it is admitted that these are examples of soils from five particular spots, it is nevertheless evident that the percentage of total phosphoric acid in the soil of the farms is not abnormal, and that they cannot be said to be *exceptional* soils.

A further point may now be taken into consideration, namely,

Proportions "available."

"what proportion of the total phosphoric acid in these Indian soils is "available?" and is that proportion about the same or different from what Dr. Dyer found to be the case in the Rothamsted soils? Looking over Dr. Dyer's analyses, I see that of the total phosphoric acid in the soils of the *manured* plots, about $\frac{1}{4}$ or $\frac{1}{3}$ was "available," whereas in the case of the unmanured plots, only about $\frac{1}{10}$ of the total phosphoric acid was "available."

The Indian Farm soils which have been referred to are examples of either unmanured, or at least but very *slightly* manured land, and in no case equivalent to the *manured* plots at Rothamsted, rather, on the contrary, do they more nearly approach to the unmanured plots at Rothamsted.

Turning now to the analyses of these soils, in those from Manjri from $\frac{1}{3}$ to $\frac{1}{2}$ of the total phosphoric acid was "available," in the Dumraon soil about $\frac{1}{4}$ of the total phosphoric acid was "available," in the unmanured Cawnpur Farm soils, from $\frac{1}{4}$ to $\frac{1}{3}$ of the total phosphoric acid was available, in those of the Meerut soils, which contained large amounts of phosphoric acid, the proportion is very much higher; in those containing less phosphoric acid, the proportion varies generally from about $\frac{1}{5}$ to $\frac{1}{3}$. In the unmanured land at Nagpur, only about $\frac{1}{16}$ was available, but in this case a process of exhaustion had been going on for some years. Thus it is seen that, although most of these soils (excluding the rich Meerut soils) contained rather small percentages of *total* phosphoric acid, they not only generally contain more than the standard ·01 per cent. of "available" phosphoric acid, but also that the *relative* amount of "available" phosphoric acid is high.

Usually up to Dr. Dyer's standard

It has been pointed out that the farm soils named are, in no particular exceptional, and indeed they may be considered as fair samples of the Gangetic alluvium and of the *regur*, respectively; it may then be fairly assumed that in these two great types of Indian soils about $\frac{1}{3}$ or $\frac{1}{4}$ of the total phosphoric acid is generally "available." The importance of these considerations will become the more evident if reference is now made to the analyses of the alluvial and *regur* soils in Statements Nos I. and III.

It will then be seen that if $\frac{1}{4}$ of the total phosphoric acid be generally "available", it is only rarely that we find a soil deficient in this plant food, and thus, although the Indian soils have frequently or generally a low proportion of *total* phosphoric acid, it is likely that the proportion of *available* phosphoric acid is not usually deficient.

Probably alluvium and *Regur* usually contain enough "available" Phosphoric acid.

It would of course not be proper to assume a similar deduction for the red soils of Madras and the laterite soils, since the "available" phosphoric acid has not been determined in any soil of these two classes.

The deduction regarding the amount of *available* phosphoric acid is also quite in accord with the fact that at one farm only (namely Burdwan) have bones been found to be of any service as manure. At each of the other four farms bones have regularly been applied to certain plots in the field experiments, and in no case has it been found that a materially increased outturn results from the application.

This does not apply to other types.

other six samples the proportion was much less. Of the 18 samples of *regur* soils, one only contained ·05 per cent., the other 17 containing less; among the red soils from Madras one contained ·05, the other 5 less; among the 12 laterite soils not one contained as much as ·05 per cent., and most of them only about ·03 per cent. or less. On the other hand the Assam soils contained uniformly high proportions of nitrogen, and those soils which have had an opportunity of accumulating nitrogen contained very fair amounts. The soil from Partabgarh contained ·18, the surface soil at Changa Manga ·237 and the coffee soils from the Sheveroys ·04 to ·17. Thus the opinion to which Dr. Voelcker came, namely, that Indian soils are generally very deficient in nitrogen content is amply supported. Moreover, if the analyses of the other soils which are quoted in paras. 32-35 namely, the farm soils, and those from the Meerut district, be examined, the same tale is told. Among the soils from the Meerut district (para. 45) some of the clays contained more than ·05, but none so much as ·1 per cent., and the proportion in the more loamy soils falls considerably below ·05 per cent. The soil at Manjri (Poona) when first taken up for the Sugar-cane experiments contained ·035 per cent. or less (*vide* para. 33) The soil of the new Farm at Dumraon contained about ·045 per cent. (para. 36).

Dr. Voelcker's opinion supported.

SPECIAL CASES.

43. The following special cases relating to soils have been submitted to me:—

The first is one of some land in the Amherst District, Burma, which is thus described by the Settlement Officer.

Copy of a letter No. 93-1—26, dated 1st April 1896, from the Settlement Officer, Amherst District, Maulmein, to the Reporter on Economic Products to the Government of India.

Burmese soil near hot springs.

I have the honour to advise the despatch to your address on the 28th ultimo of a case containing certain specimens of soil and water connected with the cultivation of onions and tobacco, which would probably be of some interest.

In the neighbourhood of Yebu village, Gyaing Attaran township, Amherst, are some hot springs or tanks of boiling water, a description of which will be found in the *British Burma Gazetteer, Vol. 1.*

Description of locality.

The springs are found in low rising ground in the middle of an inundated plain, and the soil immediately round them is laterite. In the immediate neighbourhood of these tanks from which the water bubbles off on the low ground below or is carried into the river *Attaran* by a nullah, are cocoa-nut and betel-nut plantations. The cocoa-nuts have the same flavour as those found near the salt water in the Gulf of Martaban. The soil is only about four feet in depth, and below that water is reached. I send you a specimen of subsoil No. 3 about eight inches below the surface. On the lower ground on either side the water is too deep in the rains to work any crop, but immediately the water subsides, drains are dug round the plantations and the surface soil dug up with a *mamoti* and the earth thrown up in ridges, on which onions are planted; the crop is taken in February and then a crop of tobacco and chillies, mixed with maize and country vegetables is planted. The specimens now sent were taken in the month of March while the second crop was on the ground, and are, first, a specimen of low lying surface soil No. 1 (*b*) taken from Nga Kannas' field in which a crop of tobacco mixed with maize is planted after the onion crop was taken, and secondly, a specimen No. 2 of high lying hard soil taken from Nga Gunnas' field, in which chillies and country vegetables were planted after the onion crop was taken; about two feet to three feet below the soil, water is reached. The cultivators say that they cannot work the same soil more than five to six years continuously, and not as long as that. The soil gets worn and the crop is poor and will not produce without a long rest. I cannot, however, give any confirmation of this. They say that, if salt water is let into the fields again, it has no fertilising properties, and the land cannot be continuously worked by this means. I also send a specimen of the boiling water from the springs, No. 2, and of water *taken from the drain leading past the cultivation* No. 3. I should be glad if you could let me know the result of any analysis you make for insertion in the Settlement Report.

The onions grown are the small red onions and sell at Rs. 10 to Rs. 15 per 100 viss,* they say, and the tobacco sells at Rs. 1 per viss, local sale. The cultivation covers only a small area.

The following report which was subsequently submitted, explains the composition of the water and soils in question.

* One viss equals 3·65 lbs. Avoirdupois.

SOILS. | On the Composition of

The accompanying statements contain the results of the analysis of the samples of water and soils.

	W. No. 2	W. No. 3
	Parts per million.	
Total residue	2,750	2,780
Loss on heating	580	570
Oxygen absorbed	12	·6
Sodium Chloride	5	10
Calcium Sulphate	1,485	1,492
Calcium Carbonate	158	133
Sulphates of Magnesia and Alkalis	450	390
Sand	30	60
Sulphuretted Hydrogen	6	0

The water.

Considering in the first place the water, I must explain that "No. 2" and possibly also "No. 3" had changed somewhat in composition before it was analysed. No. 2 contained sulphuretted hydrogen, and this substance changes somewhat easily in contact with the air. No. 3 contained no sulphuretted hydrogen when analysed, but may have contained it when put in the bottle. As the analysis shows, both waters are of practically the same composition, excepting of course in respect of the sulphuretted hydrogen, and they contain very considerable amounts of calcium sulphate (gypsum) with lesser, though still large amounts of sulphates of magnesia and the alkalis. What the exact circumstances may be under which these hot springs are formed, I cannot say. Doubtless, however, the sulphuretted hydrogen is formed by the action of steam and carbonaceous matter on the gypsum, and then as the water flows out of the spring and over the ground, the sulphuretted hydrogen becomes in part dissipated, in part re-oxidised, and the latter combines again to form sulphates.

Sulphuretted Hydrogen.

Indian Soils. (*J. W. Leather.*) **SOILS.**

Composition of the Soils.

	No. 3.	No. 1 (b).	No. 2.
Silicates and Sand	21·35	59·61	65·75
Oxide of Iron	28·11	2·08	1·49
Alumina	4·65	13·11	12·16
Oxide of Manganese	·14	—	—
Lime	18·79	·85	·87
Magnesia	3·00	·72	·63
Potash and Soda	1·06	1·51	1·27
Phosphoric Acid	1·06	·06	·05
Carbonic Acid	13·09	·02	·03
Organic Matter and Combined Water	8·75	22·04	15·25
	100·00	100·00	100·00
Nitrogen	·19	·51	·41

No. 3 peculiar.

Regarding in the next place the soils, that which is numbered 3 contains a very exceptionally large amount of oxide of iron, also a very large amount of calcium carbonate and a very small proportion of silica. I conclude from the Settlement Officer's letter, however, that it is in regard to the composition of the other two soils, numbered 1 (*b*) and 2, that information is more particularly required. They are quite different from No. 3 and are of a more ordinary description. Both contain a low proportion of oxide of iron and a high proportion of alumina, with a high proportion of organic and nitrogenous matter; the amount of sand is low as also is the amount of phosphoric acid. They are, I imagine, stiff clays and difficult to work.

No. 1(b) and 2 ordinary.

Excepting that the amount of phosphates is low, they are not (chemically) poor soils. But if, as I understand, the water from the hot springs flows over these lands, a reason is apparent why the people find a difficulty in raising crops on these soils. There is nothing more prejudicial to plant life than sulphuretted hydrogen, and if the water brings this over the land, the crops are bound to become affected.

There is, it seems to me, only one way out of the difficulty, and that is to keep this water from the springs away from the land. Whether this is possible, I cannot of course say, but if it be possible, then, I should expect the land to be improved rather than injured by cultivation. It is, however, a soil which will always require good, *i.e.*, expensive, tillage. It is one which requires as much exposure to the sun and air as one can give it.

44. Another case of infertility was referred to me by the Conservator of Forests, School Circle.

Copy of a letter No. 287, dated 5th March 1897, from the Deputy Conservator of Forests, Dehra Dun Division, to J. W. Oliver, Esq., Conservator of Forests, School Circle, North-Western Provinces and Oudh.

I have the honour to send herewith three samples of soil for analysis by the Agricultural Chemist. They were collected by me from the top soils of three separate places in compartments 16 and 17 in the Dholkot Forests.

Dehra soil.

2. I have numbered them both inside and outside.

Sample No. 1 was collected from the top soil of an open glade surrounded by tall *sál* trees, the spot being perfectly open above and within easy reach of falling *sál* seeds.

The spot contained no young growth.

Sample No. 2 was collected from a similar spot, but the young growth was of medium quality.

Sample No. 3 was collected from under a very thick growth of young *sál* trees about 25 feet high.

3. Kindly let me know the results of the analysis,

As the following report shews the infertility of the land was due to natural poverty of the soil:—

Analyses of samples of Soils from the Dholkot Forests.

	No. 1.	No. 2	No. 3.
Nitrogen (total)	·043	·101	·152
Available Phosphoric Acid	·026	·028	·048
Total Phosphoric Acid	·105	·112	·144
Calcium Carbonate	·187	·293	·685

The soil No. 3 is the richest and No. 1 the poorest in plant-food, and this will probably explain why the latter does not produce so much young growth.

MEERUT SOILS.

45. In 1895 Mr. Wyer, the Collector of Meerut, sent a number of samples of soil for analysis. It was impossible to make complete analyses of so many, and therefore only the proportions of the most important ingredients were determined. The following is a copy of the report which I submitted on them, and the Settlement Officer's reply is also added.

Copy of a letter No. 426, dated 12th March 1897, from the Agricultural Chemist to the Government of India, to the Settlement Officer, Meerut.

I have now the honour to forward the results of my examination of the samples of soils which were forwarded by Mr. Wyer, on 15th April 1895. (*Vide* statement XVI.)

2. This list is arranged according to the physical characteristics of the soils, and the analyses indicate that, so far as mere chemical constituents are concerned, the clayey soils are the richest in plant-food, which is a characteristic of clay soils generally in other countries.

3. Of course any advantage which a soil may possess in respect of its richness in plant food, may be quite outbalanced by accumulations of the objectionable soda salts, known as "*kallar*" or "*reh*."

4. I should feel much interested to know in how far the value which you have placed upon these soils agree with the chemical analyses.

Meerut soil Map

5. I should have been glad to compare the analyses also with the soil map of the Meerut district, which is reproduced in the last settlement report, but the exact places from which the soils were taken has not been forwarded to me. For example, 4 samples were from Loni village, one being a grey clay, another a grey (sandy?) soil, a third yellow "burya" *usar*, and the fourth a yellow sandy soil. The village Loni apparently touches two very different tracts, and therefore I am unable to tell which of these samples belong to one tract, which to the other.

Copy of letter No 346 A.—3-5, dated 18th June 1897, from the Settlement Officer, Meerut, to the Agricultural Chemist to the Government of India.

I have to thank you for the very interesting list of soil analyses sent with your letter No. 426, dated 12th March 1897, and regret that by an oversight it has been left so long unanswered.

Settlement values.

2 It is rather difficult to answer your question, how far the value placed on the different soils agrees with the chemical analyses. These relative values vary from *pargana* to *pargana* and are affected by several conditions. For instance the outstanding distinction throughout the district is that between irrigated and unirrigated, the difference being often double and never less than one and-a-half; if nearly the whole area is irrigated in any particular tract, it is probable that there will be little difference in the rates paid for good and bad dry soils, the reason being, as I understand, that there are certain crops which are always grown on dry soil, and the necessity of growing these forces up the rate on bad soil almost to the level of the rate on good.

3. The difficulty of answering your question is increased by the fact that the only village on your list which I have examined in detail is Dastoi, *pargana* Sarawa. This is a fairly fertile village, certainly above the average, and I am surprised that the analysis of the soils does not show better results; perhaps they were not typical specimens Perhaps the best way of giving you an idea of the relative values placed on the different soils is to quote the rates at which land is actually leased in the *parganas* in which I find that most attention is paid to natural

distinctions, Puth and Garhmuktaishur. In these *parganas* the rates are :—

Best *loam*, irrigated	*Rs. 12 per acre*	
„ dry	„ 6	„
Second class loam, wet	„ 9	„
„ „ dry	„ 6 to 4-12 per acre.	
Sandy loam or superior sandy soil, wet	Rs. 6	per acre.
„ „ „ dry	„ 3	„ „
Inferior sandy soil, dry	„ 2 to 1-4	„ „
Clay, wet	„ 9 to 6	„ „
„ dry	„ 6	„ „

These are the rates in the best villages but the proportions are much the same, though the rates are lower in those which are inferior.

4. The case of clay may be specially noticed, as analysis shows it to be particularly rich in plant-food. Here I can say without hesitation that the relative value I have given for two *parganas* prevails throughout the district. Dry *dakar*, as it is called, pays as high a rate as the best dry soil, wet *dakar* always pays something below the rate of the best wet soil; generally speaking about a fourth less. On the whole it is regarded as an inferior soil, and the reason no doubt is that it always lies in depressions and is liable to damage from excess of water. The reason why the dry *dakar* rate is high in proportion is no doubt that under normal circumstances it can produce valuable crops without water. The most distinctive crops grown in *dakar* are rice and gram and, although no doubt in years of deficient rain-fall the rice will fail without irrigation, yet in an ordinary year it is probable that it gets as much water as it requires. Irrigation in the case of gram is of course exceptional

5. I have looked up the old Settlement Report, but cannot find the soil map you refer to. I do not know that it would be of much assistance. There are, of course, tracts of extraordinarily uniform soil—witness the *parganas* of Baraut, Chaprauli and Katana, or at least as much of them as is not affected by the action of water on *the ravines of rivers, but as a general rule the soil varies rapidly from* village to village, and it is no uncommon thing to find one village containing all gradations of soil from the most incoherent sand to the very richest loam. I do not know who selected the samples of soil, but I think the selections might have been more typical. The richest part of the district, for instance, is undoubtedly the part of Baraut, Chaprauli and Katana to which I have referred; it has been called the richest tract in the North-West Provinces. There we have also, as I have said, a singularly uniform soil, and the analysis of a soil

sample taken from any part of the tract might fairly have been considered applicable to a larger area than in the case of a sample taken from any other part of the district, but I see that you have not had a single example from there. The only village, in fact, of which you have a sample from the whole of that *tahsil*, is Baghpat itself, and Baghpat being a village on the ravines of the Jumna, with rapidly varying soils, is, in my opinion, a very bad village from which to select a soil specimen.

STATEMENT No. X

Composition of Meerut Soils.

Laboratory No.	Description of Soil.	Village	Pargana.	Total Nitrogen.	Total Phosphoric Acid.	Available Phosphoric Acid.	Available Potash.
309/96	Grey Clay	Loni	Loni	·064	·484	·340	·200
328	Ditto	Bagpat	Bagpat	·035	·131	·024	·020
323	Ditto	Sarsat Dargada	Barnawa	·064	·310	·157	·061
304	Ditto	Jellalabad	Jellalabad	·055	·146	·066	·033
308	Ditto	Dhulana	Dasna	·044	·204	·123	·068
313	Ditto	Sapuawat	Ditto	·070	·110	·039	·027
318	Ditto	Shah Mohayuddinpore	Hapur	·076	·120	·045	·019
319	Ditto	Dastoi	Sarawa	·035	·069	·016	·016
316	Ditto	Sapuawat	Dasna	·053	·501	·432	·068
310	Ditto	Dhulana	Ditto	·051	·536	·411	·119
[illegible]	Grey Clay (Sotha[illegible]	Jellalabad	Jellalabad	·091	·544	·480	·115
[illegible]	[illegible]	[illegible]	Loni	·038	·421	·209	·111
[illegible]	[illegible]	[illegible]	Jellalabad	·027	·110	·041	·015
[illegible]	[illegible]	[illegible]	Dasna	·068	·310	·230	·070
[illegible]	[illegible]	[illegible]	Ditto	·035	·061	·010	·014
[illegible]	[illegible]	[illegible]	Loni	·021	·142	·047	·028
[illegible]	[illegible]	[illegible]	Ditto	·032	·151	·145	·013
307	Red loam	Ditto	Ditto	·037	·067	·015	·010
311	Yellow loam	Ditto	Ditto	·038	·110	·044	·016
312	Ditto	Ditto	Ditto	·041	·241	·145	·035
324	Red loam	Bagpat	Bagpat	·041	·041	·032	·042
325	Ditto	Ditto	Ditto	·035	·061	·017	·007
321	Yellow loam	Banoli	Barnawa	·048	·068	·015	·012
327	Red loam	Ditto	Ditto	·034	·080	·022	·016
302	Yellow loam	Jellalabad	Jellalabad	·039	·096	·042	·042
315	Red loam	Sapuawat	Dasna	·034	·065	·011	·005
326	Grey loam	Meerut	Meerut	·037	·092	·055	·018
297	Red sandy	Sharf Din Badar Chhawani	Loni	·023	·060	·031	·008
309	Yellow sandy	Loni	Ditto	·029	·068	·014	·012
330	Grey sandy	Ranchhor	Barnawa	·034	·090	·062	·015
300	Red sandy	Jellalabad	Jellalabad	·034	·072	·043	·011
317	Yellow sandy	Shah Mohayuddinpore	Hapur	·020	·067	·027	·002
320	Red sandy	Dastoi	Sarawa	·025	·047	·005	·018
329	Yellow calcareous	Bagpat	Bagpat	·033	·104	·016	·014
322	Ditto	Prichhatgarh	Khator	·046	·045	·003	·008

THE "CHOS" LANDS OF HOSHIARPUR DISTRICT.

46. At the end of 1894 I received samples of soil from three places in what are known as the Hoshiarpur *Chos* lands. These lands are the production of excessive deposits of sand, brought down by rivers from the Himalayas, on the top of the older agricultural soil of this part of India The investigation was undertaken with a view to determine what difference there was between the newly-deposited sand and the older soil. Cause.

The following report, which was submitted in August 1895, contains the results of the investigation, to which is added a letter from the Deputy Commissioner on the subject of how long a time is required for the newly-deposited soil to become fertile:—

Report on the composition of six samples of soils from the "Chos" lands of the Hoshiarpur District, Punjab, which were forwarded by the Deputy Commissioner in November 1894 to the Agricultural Chemist to the Government of India

The accompanying statement (No. XVII) exhibits the results of the chemicalanalyses which I have made of the above-mentioned soils. I have not yet had an opportunity of personally inspecting these lands, but I understand that they are subject to periodical floodings from the hill streams, and that it frequently happens that the silt left behind by the subsiding water is of a very sandy nature, so much so that good land is frequently covered with al oose sandy soil, the latter being agriculturally inferior to the older soil.

I suggested that samples should be sent to me from different spots, of which one (in each case) should be a sample of the newly-deposited soil, or what is now the "surface" soil, the other should be a sample of the older soil, which had become covered up, and which is now the sub-soil. Method of Sampling.

Three such pairs of samples were sent to me by the Deputy Commissioner of Hoshiarpur, in November 1894, which bore the labels "Hoshiarpur," "Dosuya", and "Garshankar," respectively, but I have not been informed at what depth the "sub-soil" samples were taken. I presume, however, that these latter were not at any great depth, but are found at some 12 to 24 inches below the surface. Sources.

Considering in the first place the mechanical condition of these

soils, the soil from Hoshiarpur and Dosuya were distinctly different from those from Garshankar.

Physical appearances.

The soil from Hoshiarpur was a light grey coarse sand at the surface, its sub-soil being somewhat darker, much finer, but still sandy The soil from Dosuya was a light grey course sand at the surface whilst its sub-soil was of a red colour, much finer, but still sandy. The surface soil from Garshankar was sandy, but reddish brown and much finer than the surface soil at Hoshiarpur and Dosuya, its sub-soil was very similar to it. Thus it seems that there is a similarity between the soils at Hoshiarpur and Dosuya which are, especially at the surface, much coarser sandy soils than that at Garshankar. In the statement of analyses, the pairs follow one another Column 2 contains the result of analysis of the surface soil at Hoshiarpur, Column 3 those of its sub-soil; Column 4 those of surface soil from Dosuya, Column 5 those of its sub-soil, Column 6 those of surface soil from Garshankar; Column 7 those of its sub-soil

Method of comparison.

In considering in what manner chemical analysis would best throw light on the respective merits of these soils, I decided to determine in each case the proportion of phosphoric acid and of potash which is readily or immediately available to plant life, and also in each case the *total* amount of phosphoric acid and of potash contained in them. I have also determined the amount of potash which is soluble in hydrochloric acid. This, like the proportion of "available" potash, indicates the relative extent to which these soils have decomposed.

The former determinations would thus show the relative *present* value of the soils, the latter would indicate whether the newly-deposited surface soil might eventually become as good as the older soil, if it should be inferior at the present time.

I have also determined the amount of nitrogen in these soils. There is at present no means of determining what proportion of the nitrogen in a soil is "readily available" to plants, and the figures in the statements all refer to the total amount of this constituent.

Nitrogen.

The further study of the figures in the statement is now simple In the case of the nitrogen, it will be seen that in each case the surface soil contains very much less nitrogen than its sub-soil, and, moreover, that the soils at Hoshiarpur and at Dosuya contain very much less nitrogen than that at Garshankar The proportion of

phosphoric acid is not quite so regular. At Hoshiarpur the surface soil contains approximately as much of this constituent, whether readily available or not, as its sub-soil. In the Dosuya samples whilst the total amount of phosphoric acid is somewhat less in the surface soil than in the sub-soil, the amount readily available is much more. In the samples from Garshankar we find considerably less phosphoric acid, both "readily available" and total in the surface than in the sub-soil. In the case of the potash, however, we meet with greater uniformity. The proportion immediately available is much less in the surface soils at Hoshiarpur and at Garshankar than their respective sub-soil; the respective proportions in the Dosuya samples are equal and at the same time very small. The proportions of potash "soluble in hydrochloric acid," which includes much more than what is immediately available to plants, are in each of the three cases much less in the surface soils than in their respective sub-soils. Lastly, the proportion of total potash, though they vary somewhat among the samples, appears to be much about the same. The sub-soil at Dosuya contains less than the others, but this may be accidental.

Phosphoric acid

Potash.

In conclusion, it would appear generally that the surface soils are agriculturally distinctly poorer than the sub-soils, at present, but that they will eventually become as good. They are, in two cases especially, very much coarser, and this means that they would dry very rapidly indeed, for they will not prevent water from passing downwards, and it will also evaporate much more quickly from their surface. The proportion of nitrogen is as usual in Indian soils, very low indeed, but it is not lower than I should have expected.

Top soil poorer than sub soil

The total amount of phosphoric acid is not high, but it appears to be generally in a readily available form.

The total amount of potash lastly is distinctly high, as is also that portion of it which is soluble in hydrochloric acid. The portion immediately available is in all cases fully ample for the requirements of average crops of cereals. The most important question in relation to these soils is "at what rate do they disintegrate and decompose"; i.e., how soon may these new deposits be expected to become agriculturally equal to their sub-soils? If any information can be gained on this point, it would be most valuable.

Copy of a letter No. 145, dated 22nd May 1896, from Captain E. Inglis, Deputy Commissioner, Hoshiarpur.

Length of time required for new-soil to become food.

With reference to your office endorsement No. 2446, dated 14th September 1895, on Dr. Leather's Report on analysis of soils of Hoshiarpur *Chos*, I have the honour to report that a cultivated area, converted by *Chos* into pure sand, if properly planted with *kharkana* and manured with cow-dung, becomes fit for cultivation within 8 or 10 years, as observed in villages Naloian, Mazian and Dual. But as regards resuming its original fertility it takes much longer. This period is estimated not less than 50 years.

STATEMENT No. XVII.

Analysis of Samples of Soils from the Hoshiarpur District, Punjab.

	HOSHIARPUR.		DOSUYA.		GARSHANKAR.	
	(401) Surface soil.	(402) Sub-soil.	(403) Surface soil.	(404) Sub-soil.	(405) Surface soil.	(406). Sub-soil.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Nitrogen . .	·0065	·013	·0065	·023	·031	·067
Equal to Ammonia	·0078	·018	·0078	·027	·037	·081
Phosphoric acid available.	·015	·018	·021	·004	·038	·136
Phosphoric acid total.	·080	·073	·036	·049	·069	·261
Potash available.	·0092	·0215	·0069	·0065	·0499	·166
" soluble in Hydrochloric acid.	·137	·461	·156	·336	·412	·979
Potash total .	2·230	2·809	2·917	1·845	2·422	2·529

THE EXHAUSTION OF INDIAN SOILS.

47. The question whether the soil of India generally is becoming exhausted has been raised and discussed by more than one person, and is the somewhat natural outcome of the fact, which is at once brought to the notice of any one who visits India, namely, that a large part of the cattle manure is used as fuel. Clearly on the face of it, if "exhaustion" be taking place, it is a slow process, and strictly speaking one could only determine the matter by very careful observation and experiment carried on for a long period. It will be equally clear that it would have been impossible for me in the few years at my disposal to attempt such a series of experiments.

At the same time since I have had an opportunity of spending several years in India, it will not be out of place if I set out very briefly the views on the subject which I have come to hold, views I may observe which are in most respects in accord with those expressed by Dr. Voelcker, but to which I shall add something.

48. In the first place it will be well to refer for a moment to the opinion which Professor Wallace of Edinburgh (who spent 4 months in India in 1885 or 1886) expressed in his book entitled "*Indian Agriculture*" He says (chapter 13, page 158) "One very important question with regard to India still continues to be asked: Is the fertility of the soil being exhausted by the native practices that have been going on for thousands of years? My unqualified answer is "No." He then proceeds to explain what he refers to under the term "soil," and describes in detail the process of surface washing which occurs annually throughout India. He concludes the paragraph with the words "By cropping in the ordinary way the native fertility of a soil cannot be lowered." The following paragraph, however, makes an all important explanation of what Professor Wallace means by "native fertility." "Temporary fertility the qualities possessed in virtue of some accumulation of material useful to plants, may be dissipated, but when this is gone no system of cropping can reduce the land to a lower point. The greater portion of the land in India, which is not newly broken in, annually produces its minimum yield. Where declining fertility has been recorded, it was no doubt due to loss of temporary fertility which had accumulated during a period of rest." This second paragraph then contains the all important admission that although the fertility of Indian soil is not being exhausted, still it can become more fertile by rest, and that formerly it contained a store of *temporary* fertility which has now gone, and that the land has reached a certain level below which it cannot descend.

Professor Wallace's opinion.

Fertility not being exhausted.

Temporary fertility.

I may here observe with regard to the distinction which Professor Wallace makes between *temporary* and the *natural* fertility of soils, that it is one which no other authority on agricultural subjects (so far as I am aware) has expressed, and it is clearly only a question of *terms*. The *natural* fertility of a soil, which Professor Wallace says cannot be destroyed, certainly includes more than the mere rocky particles of which a soil is composed, for some organic matter is certainly

Impossible to define temporary fertility

also a component part, and how one is to distinguish between this portion of organic matter belonging to the *natural* fertility, and that other portion of organic matter which belongs to Professor Wallace's *temporary* fertility, is a problem which it is quite impossible to solve, since they both are the product of the decay of plants or parts of plants in the soil The presence of a store of " temporary " fertility in the past *may* or may not be the case ; the opinion that a soil cannot be reduced in fertility below a certain level is one for which there is absolutely *no* proof , on the other hand, we have the *fact* that in the Rothamsted and Woburn Experimental Fields in England the crops which have been grown for so many years without the aid of manure do annually become less and less, and the limit (if there be one) has not so far been reached.

Nitrogen in Rainfall

Rothamsted

Madras

Calcutta.

49. This fact is pointed out by Dr. Voelcker, and he further examines three questions which have a close relation to the main one. The first is " How much nitrogen is added to the soil by rain." The rainfall at Rothamsted brings annually about 4·5 ℔ of nitrogen to the land. For some time it was contended that the rain in India brought very much more than this, and figures, which were afterwards proved erroneous, were quoted in support of the fact. Later determinations by Dr. Van Geyzel of Madras showed in 1888 4 ℔ and in 1889 only 2·1 ℔ per acre of nitrogen to have been so deposited ; later in 1891 Mr. Bamber, then Chemist to the Indian Tea Association, Calcutta, found that the nitrogen in the rain-fall from May to October was equal to 3·4 ℔ ammonia. Thus then it is practically certain that no large amount of this all-important plant food is added to the soil from this source.

Effect of growing pulses

The second point which bears upon the question is " What is the effect of growing such large quantities of pulses and other leguminous plants in India ? What amount of nitrogen is supplied indirectly by this means to other crops ? " Unfortunately, there is no answer to this question at present. All that one can say is that, knowing as we do that the members of this natural order *do* assimilate atmospheric nitrogen, they are a means of adding this plant-food to the soil, and doubtless it forms a very important item in relation to Indian agriculture.

Effect of exporting grain.

50 The third point which has been brought into the discussion is the effect of the export of grain, oil-seeds and bones from India.

Dr Voelcker considers, as others have done, that this forms a serious loss. He says (para 51) "On the one hand there is a large export of oil-seeds, cotton and other products besides an increasing one of wheat, all of which remove a considerable amount of the soil constituent What is returned in their place? Only the straw or the stalks and leaves, and it is not even correct to say that these are *returned, for, after all, it is only a portion, and frequently a very* small portion, that does find its way back to the soil Part is necessarily used up in the bodies of the cattle, part is wasted by imperfect conserving and storing of manure, part must unavoidably be lost, however great the care that may be taken, thus it comes about that it is only a fraction that contributes finally to making up the loss the soil has sustained. Were, on the contrary, all grain to be consumed by the people, and all night-soil to be used in agriculture; were all refuse of oil-seeds (after pressing out the oil) to be utilised for manure; were all straw to be consumed by cattle, and the droppings, solid and liquid together, to be carefully preserved; lastly, were all stalks and leaves to be buried again in the land, then the balance might be more nearly preserved. But, as things are, the exports of oil-seeds grain, etc. (that of bones I will discuss later), simply mean so much of the soil constituents carried off, for which no adequate recompense is made

To my mind this matter of export of [illegible] been gauged as far more serious than a consid[illegible] the case will allow In the paragraph just quo[illegible] Report he says that if the residual matters of the crops produced in India were returned to the soil, the balance would be maintained, and it is clear that one may take this to be a fundamental fact. But it is also clear that export of agricultural produce out of India can only become a serious item *when it removes a material proportion of the plant-food which is extracted by each crop.* Now what is this proportion? *In a paper entitled "Memorandum on the Resources of British India,"* Dr. Watt makes an estimate of 5,72,15,000 tons as the production of food grain, which however Dr. Watt does not consider very accurate I myself think it may be somewhat too high. Nevertheless, it is not so utterly wrong as to be worthless for the purpose in question. The total exports of food grains is about 25,00,000 tons, or roughly 5 per cent. of the production, and accordingly some 5 per cent. of the plant-food which the grain of the crops annually extracts; Reasons

Actual amount of plant food exported

from the land is exported. Now what is the amount of plant-food which grain crops in India take up to form their substance? If we allow it to be some 15 lb of nitrogen and half that amount of phosphoric acid per acre (which are the only items that need be taken into account) such an estimate cannot be considered too low; indeed it is in all probability too high. This is the amount, moreover, which is taken up by the whole crop (straw included). Since only grain is exported, it follows that it is not 5 per cent. of the abovenamed quantity, but 5 per cent to a still smaller figure (probably $\frac{2}{3}$ or $\frac{3}{4}$ of it) which would represent the drain of these plant-foods per acre caused by export, or in other words it will not be much more than half a pound of nitrogen and quarter of a pound of phosphoric acid per acre per annum, and may be it is less than this! Such quantities as these are in all probability amply replaced by nature.

A similar result is obtained if one calculates, from the known amounts of nitrogen and phosphoric acid in the exported grain, the amount of these substances per acre But by deducing the figures in the manner adopted, it is more clearly brought out how small a proportion of materials, required for the grain crops of India are thus taken out of the country.

Loss made up for by natural means

It has already been mentioned that the rainfall brings down annually several pounds of nitrogen per acre and this agency alone much more than makes up for the loss of this element caused by export. And in the case of the phosphoric acid, the annual movement of silt from higher to lower ground on to the land by the monsoon rainfall must be admitted to be a source of mineral plant-food.

Thus there can hardly be any doubt that the export of food grain from India has been considered to be a far more serious drain than it really is

Export of bones.

And similarly in the case of bones, quite apart from the fact that at only one of the five experimental farms has this material been found of any value as manure, if the amount of phosphate exported be referred to the acreage, it will be at once evident how utterly impossible it is that this trade can be exercising any influence on the fertility of the land

51. To my mind it is much more important to consider how the fertility of the land can be increased, than to consider whether the land is becoming exhausted. "Exhaustion" is a purely relative term; it is highly improbable that in any process of agriculture a certain level is finally reached below which fertility cannot descend, and it

would be much more correct to say the fertility of the land in India is not only low compared with that of other countries, but that if it is not *decreasing*, it is certainly not *increasing*. It must also be admitted that with a better supply of manure fertility would be *immediately* increased and more grain produced per acre. And for that better supply of manure there is only one principal source, namely, the dejecta of the human beings and animals that consume very nearly the whole of the grain crops, straw included.

Fertility would be increased by manuring.

It is in the more perfect direct (not indirect) return to the land of these matters that one can look for an increased manure supply, an increased fertility, an increased outturn of food grain. Doubtless under present circumstances there are many difficulties to be overcome before anything like great economy will be realised in this direction. There is the scarcity of fuel which occasions the loss of nitrogen and organic matter of a very large proportion of the dung of agricultural animals, there is doubtless a great deal of carelessness among cultivators (more in some parts than in others) as to the preservation of such refuse materials as are not burnt; there is a similar want of method practised in relation to the night-soil. These difficulties may some day be removed. In the meantime they *must* remain an acknowledged fact, and that but for these obstacles the land *would* be more productive than it is. Further, so far as nitrogen is concerned, it may be kept in mind, that of the other two sources of this element, the rain is annually giving several pounds per acre, and that the LEGUMINOSÆ are also beneficial in a like direction. But to what extent they are thus beneficial is a problem which remains for future investigators to determine.

Importance of direct return to the land of animal fæces.

S. 2260 a.

G. I. C. P. O.—No. 499 R. & A.—20-6-98—2,250—H. R.

All communications regarding THE AGRICULTURAL LEDGER should be addressed to the Editor, Dr. George Watt, Reporter on Economic Products to the Government of India, Calcutta.

The objects of this publication (as already stated) are to gradually develop and perfect our knowledge of Indian Agricultural and Economic questions. Contributions or corrections and additions will therefore be most welcome.

In order to preserve a necessary relation to the various Departments of Government, contributions will be classified and numbered under certain series. Thus, for example, papers on Veterinary subjects will be registered under the Veterinary Series, those on Forestry in the Forest Series. Papers of more direct Agricultural or Industrial interest will be grouped according as the products dealt with belong to the Vegetable or Animal Kingdom. In a like manner, contributions on Mineral and Metallic subjects will be registered under the Mineral Series.

This sheet and the title-page may be removed when the subject-matter is filed in its proper place, according to the letter and number shown at the bottom of each page.

NOTICE.

Future issues of this publication placed under either the "Special Veterinary" or "Special Forest Series" will not be included in the annual enumeration. Such papers are printed for Departmental purposes. Their unfortunate inclusion in the system of annual numbering has led recipients of the ordinary issues to think their sets incomplete

The following pamphlets have already appeared as Special issues, and have not accordingly been furnished to the public :—

1894 . .	Nos. 8, 9, 10, 11, 13 and 15.
1896 . .	No. 8.

(Medical and Chemical Series, No. 12.)
(Medicinal Products.)

THE

AGRICULTURAL LEDGER

1898—No. 3.

Medicinal Series and

ACONITUM FEROX.

(INDIAN ACONITE.)

[*DICTIONARY OF ECONOMIC PRODUCTS, Vol. I., A. 397-400*]

CONTRIBUTIONS TO OUR KNOWLEDGE OF THE ACONITE ALKALOIDS.

ON PSEUDACONITINE

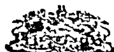
By WYNDHAM R DUNSTAN, M A F R S, *and* FRANCIS H CARR, A.I.C., *Salters' Company Research Fellow in the Laboratories of the Scientific Department of the Imperial Institute* *Reprinted from the Transactions of the Chemical Society, 1897*

Other DICTIONARY articles that may be consulted:

Aconitum heterophyllum, *Vol. I.*, A. 401.
A. Napellus, *Vol I.*, A. 413.

Also

The Agricultural Ledger Nos. 32 of 1896; and 19 of 1897.



CALCUTTA:
OFFICE OF THE SUPERINTENDENT, GOVERNMENT PRINTING INDIA.
1898.

The objects of THE AGRICULTURAL LEDGER are—

(1) To provide information connected with agriculture or with economic products in a form which will admit of its ready transfer to ledgers,

(2) To secure the maintenance of uniform ledgers (on the plan of the Dictionary) in all offices concerned in agricultural subjects throughout India, so that references to ledger entries made in any report or publication may be readily utilised in all offices where ledgers are kept;

(3) To admit of the circulation, in convenient form, of information on any subject connected with agriculture or economic products *to officials or other persons* interested therein,

(4) To secure a connection between all papers of interest published on subjects relating to economic products, and the official Dictionary of Economic Products With this object the information published in these ledgers will uniformly be given under the name and number of the Dictionary article which they more especially amplify. When the subject dealt with has not been taken up in the Dictionary, the position it very possibly would occupy in future issues of that work will be assigned to it.

(Medical and Chemical Series, No. 12.)
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THE

AGRICULTURAL LEDGER.

1898—No. 3.

ACONITUM FEROX.

(INDIAN ACONITE)

[*Dictionary of Economic Products, Vol I*, A 397-400.]

CONTRIBUTIONS TO OUR KNOWLEDGE OF THE ACONITE ALKALOIDS.

ON PSEUDACONITINE.

By WYNDHAM R DUNSTAN, M A, F R S *and* FRANCIS H CARR, A.I C., *Salters' Company Research Fellow in the Laboratories of the Scientific Department of the Imperial Institute Reprinted from the Transactions of the Chemical Society, 1897*

In previous papers communicated to this Society, an account has Introductor

varieties of aconite At the request of the Government of India, an investigation is being made, in the Scientific Department of the Imperial Institute, of the alkaloidal constituents of the chief kinds of aconite indigenous to India, especially of those which are highly poisonous, or are reputed to be of medicinal value. In this connection, Dr. H. A. D. Jowett has described (Part XIII of this series) the principal properties and decomposition products of *atisine* derived from the **Aconitum heterophyllum** of India. In a previous communication, and in the present paper, we give an account of pseudaconitine, the highly poisonous constituent of the aconite occurring in Nepaul, which is usually regarded as **Aconitum ferox,** and locally known as "*bish*" (*bikh*). Our previous knowledge of this alkaloid is almost wholly due to the researches of Alder Wright, who, in conjunction with Luff, gave an account of its properties in a paper communicated to this Society in 1878. The material employed in our

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work consisted of roots of the plant, which were specially collected with great care in the Himálayas under the supervision of Dr. George Watt, C.I.E., the Reporter on Economic Products to the Government of India

Pseudaconitine

Already noticed.

In a preliminary notice communicated to the Society two years ago (*Proc., June, 1895*) the authors described some of the properties of pseudaconitine. They showed that its hydrolysis occurs in two stages, in the first of which acetic acid and a crystalline base veratryl-pseudaconine are formed, and in the second the elimination of a molecule of dimethylprotocatechuic acid takes place with the formation of pseudaconine. It has also been shown that, when pseudaconitine is heated in the dry state, one molecular proportion of acetic acid distils over, and a base is left, to which the name pyropseudaconitine was given. This base, when hydrolysed, furnishes dimethylprotocatechuic (veratric) acid and pyropseudaconine.

Scope of this paper

The present paper gives a more detailed account of the experiments which furnished these results, and also an account of other observations on the properties of the salts and derivatives of pseudaconitine.

Extraction of the Alkaloid.—Several methods have been tried for the extraction of the base from the root, involving the use of methylic, ethylic, and amylic alcohols. Finally, a mixture of methylic and amylic alcohols, in the proportion of 5 to 1, was adopted as the most efficient solvent.

Best solvent for extraction

The methylic alcohol is distilled from the slightly warmed percolate, under reduced pressure, when a quantity of fat separates; this is removed, and the alkaloid is extracted from the amylic alcohol by shaking it with very dilute (1 per cent) aqueous hydrochloric acid. The solution is then shaken with ether, to remove the dissolved amylic alcohol, the alkaloid liberated by the addition of dilute ammonia, and then extracted by shaking with ether in the usual manner. On evaporating the dried ethereal solution, white crystals separate, which are recrystallised by dissolving them in dry chloroform, adding dry ether, and then dry light petroleum, until a slight turbidity is produced; by this means, a considerable supply of pure pseudaconitine was obtained. Judging from the yield obtained from the roots of **Aconitum ferox**, it would appear that more pseudaconitine is present in them than there is of aconitine in the roots of **A. Napellus**; but this is a question to which we shall return in a future paper.

Properties of Pseudaconitine.—The pure base crystallises well. Mr. W. J. Pope has kindly examined some fairly well-defined crystals, with the following results

Examination of crystals. Result.

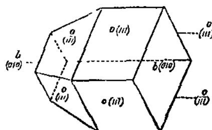
"The crystals of pseudaconitine consist of small, colourless, transparent crystals of rhomboidal shape having a rather vitreous lustre Owing to the poor character of the images obtained from the various faces, the measurements given below are of no great accuracy; they would indicate that the crystals belong to the orthorhombic system. That the crystals are, however, not orthorhombic, is shown by the faces which they exhibit, and also by the interference

figure observed in polarised light Considering, for the purpose of description, that the crystals are really orthorhombic, the following faces are always observed —(010), ($\bar{1}$0), (111), (11$\bar{1}$), (1$\bar{1}$1), (1$\bar{1}\bar{1}$), ($\bar{1}\bar{1}\bar{1}$), and ($\bar{1}\bar{1}$1), with traces of the form {110}; the two faces ($\bar{1}$11) and ($\bar{1}$1$\bar{1}$) are never observed This observation was made on all the crystals examined—ten in number, belonging to two different crops—and the same faces of the forms {010} and {111} were found in every case, this arrangement of faces is not possible in the hemihedral subdivisions of either the orthorhombic or monosymmetric system The crystals must, therefore, be assigned to the rare anorthic hemihedral system, two of the forms having the indices 111 being present as half-forms only, and the interaxial angles α, β, and γ being equal to 90° within the rather wide limits of error incurred in the measurement of crystals such as those now described

"The crystals present the appearance shown in Fig 1, and have the axial ratios—

$$a \cdot b \quad c = 0{\cdot}8362 \quad 1 : 0{\cdot}6938$$

FIG. 1



"The following angular measurements were obtained:—

Angle.	No. of measurements	Limits	Mean.	Calculated.
bo = 010 : 111	23	61° 14' — 62° 17'	61° 54'	—
oo = 111 : 111	10	54 27 — 56 46	56 5	56° 12'
bo = 010 : 111	9	117 20 — 118 19	117 58	118 6
oo = 111 : 111	18	67 12 — 68 59	68 34	—
oo = 111 : 111	7	111 14 — 111 35	111 24	111 26
oo = 111 : 111	8	94 1 — 95 29	95 35	94 29
oo = 111 : 111	4	85 2 — 8 37	85 20	85 31
pp = 110 : 110	4	78 54 — 80 16	79 20	79 48
pp = 110 : 110	1	—	101 4	100 12

"The crystals are very brittle, and possess a good cleavage; the latter, however, could not be determined On examining a cleavage fragment under a very wide angle objective one optic axis is seen to emerge at the edge of the field; it shows that the dispersion is inclined, which is only possible in the monosymmetric or anorthic

ACONITUM ferox.	The Aconite

PSEUDACONITINE

system. The hemihedral character of the crystals is of interest, because non-superposable hemihedrism is so rarely observed on crystals of the natural alkaloids, that it has been said not to occur. (Wyrouboff, *Ann. Chim. Phys.*, 1894, [vii], 1, 11.)

"The crystalline form of aconitine has been determined by Tutton (Trans., 1891, 59, 288), who found the crystals to be orthorhombic, but did not observe hemihedrism. Although morphotropic relationships would seem to exist between the crystalline forms of aconitine and pseudaconitine, yet these can hardly be worked out from the data now given for the latter alkaloid, the following corresponding angles on the two compounds seem to show some similarity.

Aconitine.		Pseudaconitine.	
100 . 121	60° 39′	010 111	61° 54′
010 : 121	57 42	100 · 111	55 43
001 : 121	46 33	001 . 111	47 15"

Melting point.

The crystals melt with decomposition at 201°, acetic acid gradually distilling off, the melting point is fairly sharp if the substance is put into the bath heated to 150° and the temperatures slowly raised Wright and Luff (*loc cit*) have recorded 104—105° as the melting point of pseudaconitine. They state that the alkaloid contains $1 H_2O$, which is lost at 100°, but we have not been able to confirm this observation

Solvents.

Pseudaconitine dissolves readily in alcohol, chloroform, and acetone, less readily in ether, very slightly in water, and scarcely

A determination of the specific rotatory power using an alcoholic solution, gave—

$$c = 1{\cdot}12 \qquad l = 2\ dm. \qquad a = 25' \qquad t = 15°$$

$$\text{whence } [a]_D = \frac{100 \times 25}{2{\cdot}1 \times 1{\cdot}12 \times 60} = +\ 18°\ 36'.$$

The ordinary salts of pseudaconitine are lævorotatory, and usually soluble in water and alcohol Combustion of the alkaloid made with the material dried at 100° gave the following results—

I. 0·2612 gave 0·5964 CO_2 and 0·1694 H_2O. C = 62·29 ; H = 7·20.
II. 0·2587 „ 0·5975 CO_2 „ 0·1484 H_2O. C = 62·96 ; H = 6·37.

Toxic properties.

These figures nearly correspond with those calculated from the formula proposed by Wright and Luff (Trans., 1878, ii, 151), namely, $C_{36}H_{49}NO_{12}$, for which the calculated percentages are, for carbon, 62·88; for hydrogen, 7·13. Like aconitine, pseudaconitine and its salts, even in very dilute solution, give rise to a persistent tingling and numbing sensation on the tongue, and are highly poisonous. From preliminary experiments on the relative toxicity of various aconite alkaloids, which have been made at our suggestion by Dr. F. W. Tunnicliffe, it would appear that pseudaconitine is slightly more toxic than aconitine.

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Alkaloids	(*Dunstan and Carr*)	ACONITUM ferox.

PSEUDACONITINE

Salts of Pseudaconitine.

Pseudaconitine hydrochloride, $C_{36}H_{49}NO_{12},HCl$ —We have not succeeded in obtaining this salt in a crystalline condition. It has been prepared by the direct action of dilute hydrochloric acid on both aqueous and alcoholic solutions of the base, but all attempts to crystallise it from water, alcohol, or a mixture of alcohol and ether have resulted in the production of a colourless varnish. — Not obtained in crystalline form

Pseudaconitine hydrobromide, $C_{36}H_{49}NO_{12},HBr$ —This salt is prepared by dissolving the base in dilute hydrobromic acid and evaporating the solution. A colourless varnish remains, and on adding a little alcohol to this, the mass rapidly becomes crystalline. It is best purified by dissolving it in dry alcohol and adding dry ether until a slight turbidity is produced, it then separates in large, cubical crystals often arranged in rosettes. The salt readily dissolves in alcohol and water, but is insoluble in ether and light petroleum. The crystals contain $2H_2O$, which are expelled on drying at 100—103° *The dried substance melts at 191°*. The water of crystallisation was estimated by heating at 100—103° in an air bath— — Mode of preparation

0·546 lost 0·0263 = 4·8 per cent. H_2O.

Determinations of the bromine in the undried and in the dried substance gave the following figures— — Bromine.

0·3379 undried salt gave 0·0751 AgBr Br = 9·44.
0·5197 *dried salt gave 0·1227 AgBr.* Br = 10·05
$C_{36}H_{49}NO_{12},HBr + 2H_2O$ requires H_2O = 4·5 Br = 9·95 per cent.
$C_{36}H_{49}NO_{12},HBr$ requires Br = 10·3 per cent.

An aqueous solution of the salt is lævorotatory; the determination of the specific rotatory power led to the following result—

$a[15°] = -15'6$ $l = 2\ dm$ $c = 0·6635$.

$$\text{whence } [a]_D = -\frac{100 \times \frac{15·6}{60}}{2 \times 0·6635} = -19° 30'.$$

Pseudaconitine, therefore, resembles aconitine in being a dextro-rota[illegible] — Similarity to aconitine

tate [illegible]
add [illegible]
thou[illegible]
line, it may readily be purified by recrystallisation from a mixture of alcohol and ether.

[illegible] C [illegible] H [illegible] NO [illegible] HNO [illegible] —This salt was pre- [illegible] dilute [illegible] acid, [illegible] er, is [illegible] is very apt to decom- [illegible] — The Nitrate.

ACONITUM ferox.	The Aconite

PSEUDACONITINE.

of alcohol; it is readily purified by crystallisation from a mixture of alcohol and ether, and when pure may be crystallised from water. The dried salt melts at 192° and effervesces at a slightly higher temperature; the melting point is fairly sharp if the substance is put into the bath at 155° and slowly heated. The water of crystallisation was determined by heating the powdered, air-dried salt at 100—105°.

0·1975 lost 0·014 H_2O H_2O = 7·0 per cent.
$C_{36}H_{49}NO_{12}.HNO_3 + 3H_2O$ requires H_2O = 6·7 per cent.

Its solubility in water at 15° was determined. 5 c.c. of a solution saturated at this temperature yielded, on evaporation, 0·209 gram of salt. 100 c.c. of water at 15°, therefore, dissolves 4·18 grams of salt

Hydrolysis of Pseudaconitine

Acetic acid.

We have previously pointed out (*loc. cit.*) that, in addition to the pseudaconine and veratric acid, observed by Wright and Luff, acetic acid is formed by the hydrolysis of pseudaconitine, and we have also shown that the hydrolysis may occur in two stages To determine the first stage only in the hydrolysis namely, the elimination of acetic acid with the formation of veratrylpseudaconine, it is best to employ a process similar to that which was found to answer in the case of aconitine A neutral aqueous solution of a pseudaconitine salt, preferably the sulphate, is heated in a sealed tube at 135° for 3 hours, the amount of acetic acid formed is determined by direct titration with N/10 alkali, and the alkaloid, after being liberated by the addition of

salt), after this
alkali = 7·5 per
cent. of acetic acid, which is slightly lower than that calculated for one molecular proportion, namely, 8·7 per cent

Silver salt

Analysis of the silver salt of this acid showed that it contained 64·56 per cent of silver. Silver acetate contains 64·66 per cent. The formation of veratrylpseudaconine may thus be represented by the following equations—



$$C_{36}H_{49}NO_{12} + H_2O = C_{34}H_{47}NO_{11} + CH_3{\cdot}COOH.$$
Pseudaconitine Veratrylpseudaconine.

Veratrylpseudaconine.

The pure base crystallises from ether in large, irregular crystals, which are nearly insoluble in water and in light petroleum, but readily soluble in ether, alcohol, and chloroform. They melt at 199° when put into the bath at 150°. A solution of the base is lævorotatory. A determination of the specific rotatory power in alcoholic solution led to the following results—

Melting point.

$t = 16°$, $a = -1°16'$ $c = 1·5035$ $l = 2·2\ dm$,

whence $[a]_D = \frac{100 \times 1·267}{2·2 \times 1·5035} = -38°18'$

PSEUDACONITINE

Rotatory power

Veratrylpseudaconine, therefore, unlike its analogue benzaconine, exhibits rotatory power of the opposite sign to that of its parent base. Aconitine and benzaconine are both dextrorotatory, whilst pseudaconitine is dextrorotatory and veratrylpseudaconine lævorotatory.

Combustions of the base, dried at 100—103°, furnished the following results, showing it to be a monhydrate—

I. Carbon 61·44, hydrogen 7·15 per cent.
II. „ 61·01; „ 7·05 „ „

Calculated for $C_{34}H_{47}NO_{11},H_2O$ Carbon 61·54; hydrogen 7·39 per cent.

Absence of toxic properties

This alkaloid and its salts have a very bitter taste, but produce no tingling sensation, and do not appear to be poisonous.

Veratrylpseudaconine Hydrobromide, $C_{34}H_{47}NO_{11},HBr$.—This salt separates from a mixture of alcohol and ether in large, prismatic crystals which contain $3H_2O$—

0·3478 salt lost 0·0264 H_2O at 100°. $H_2O = 7·5$.
0·3478 „ gave 0·0842 AgBr. Br = 11·21.
$C_{34}H_{47}NO_{11},HBr + 3H_2O$ requires $H_2O = 6·95$; Br = 11·02 per cent.

[illegible]

Melting points

rosettes. In melting, two fairly sharp points may be noticed, one at [illegible]

[illegible]

thrown down as a pale yellow, amorphous precipitate when auric chloride is added to a solution of the hydrochloride. It is insoluble in water, ether, and light petroleum, but readily soluble in ethylic and methylic alcohols, chloroform, and acetone; it could not be crystallised from any of the last-mentioned solvents alone, or on the addition of any of the former to them.

Pseudaconine

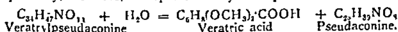
Hydrolysis

The second stage of the hydrolysis by which veratrylpseudaconine passes into veratric acid and pseudaconine, may be best effected by adding alcoholic soda to an alcoholic solution of pseudaconitine, or veratrylpseudaconine. Hydrolysis takes place rapidly, and is complete in about 2 hours. Dilute sulphuric acid is then added, the filtrate evaporated, the veratric acid extracted from the acidified solution by ether, and the pseudaconine by chloroform, after rendering the solution alkaline with ammonia.

0·2143 gram of alkaloid gave 0·0556 gram of veratric acid = 25·94 per cent. Calculated for one molecular proportion, 26·49 per cent.

PSEUDACONITINE.

The acid melts at 178° and exhibits the other properties of dimethylprotocatechuic acid (veratric acid). This stage of the hydrolysis may, therefore, be represented by the equation—



$$C_{34}H_{47}NO_{11} + H_2O = C_6H_3(OCH_3)_2 \cdot COOH + C_{25}H_{39}NO_8$$

Veratrylpseudaconine — Veratric acid — Pseudaconine.

Pseudaconine is an amorphous, hygroscopic base readily soluble in water, chloroform, alcohol and acetone, and less readily in ether. Its aqueous solution is strongly alkaline to litmus. All attempts to crystallise the base uncombined with its solvent have been unsuccessful.

An aqueous solution of pseudaconine is dextrorotatory. The specific rotatory power of an aqueous solution was determined with the following results—

$$\alpha[20^\circ] = +3^\circ 5 \quad c = 0.896 \quad l = 2\ dm.$$
$$\text{whence } [\alpha] = \frac{100 \times 0.541}{2 \times 0.896} = +30^\circ 6'$$

Pseudaconine hydrochloride, $C_{25}H_{39}NO_8$, HCl, was prepared by dissolving the base in dilute hydrochloric acid to neutrality. Many attempts made to crystallise this salt from various solvents were unsuccessful, although, on one occasion, crystals were obtained from an alcoholic solution which had stood for six months; these were prisms and melted at 68°

Attempts at crystallisation

Pseudaconine hydrobromide, $C_{25}H_{39}NO_8$,HBr, was prepared in the same

Pseud

direct act

decomposition between silver nitrate and the hydrochloride, and barium nitrate and the sulphate It was always obtained in an amorphus state

Pseudaconine sulphate, $(C_{25}H_{39}NO_8)_2$, H_2SO_4, was prepared by acting on pseudaconine with dilute sulphuric acid, but this salt could not be crystallised

Pseudaconine aurichloride, $C_{25}H_{39}NO_8$,$HAuCl_4$, is precipitated when auric chloride is added to a concentrated solution of pseudaconine

soluble

tions.

tion is

precipita

due to

chloride from the aurichloride We have so far failed to crystallise an aurichlorpseudaconine from this solution.

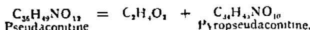
Pyropseudaconitine.

Behaviour when heated above melting point.

As previously recorded by us, when pseudaconitine is heated slightly above its melting point, it effervesces and loses acetic acid. A determination of the amount of acetic acid which distils under these

PSEUDACONITINE

circumstances, proved that one molecular proportion of acetic acid is expelled; analysis of the silver salt of the acid proved it to be silver acetate. The reaction may, therefore, be represented by the following equation—



$$C_{36}H_{49}NO_{12} = C_2H_4O_2 + C_{34}H_{45}NO_{10}$$

Pseudaconitine ... Pyropseudaconitine.

Pyropseudaconitine, an anhydride of veratrylpseudaconine, is obtained from the residue by solution in dilute acid, and is purified by fractional precipitation from this solution with dilute ammonia. The colourless fractions are dissolved in dilute acid, precipitated with ammonia, and the pure base extracted from the alkaline solution by ether. The base so far has only been obtained as an amorphous varnish, nearly insoluble in water, but readily soluble in alcohol, chloroform, and ether. Its salts appear to crystallise well; they have a bitter taste, but produce no tingling, and do not seem to be poisonous. The *hydriodide* crystallises in prisms.

Apparent absence of toxic properties

Although, in publishing our preliminary notice of pseudaconitine we stated that we were engaged in a complete investigation of the

an acetyl group. For the rest, they record melting points which differ somewhat from those previously recorded by us, but since these points are in most cases decomposing points, and depend on the conditions under which the observations are made, no real importance attaches to these discrepancies.

Another account considered

As to their assertion that pseudaconine is the anhydride of the aconine derived from aconitine, it is to be observed that this statement is based solely on the numerical coincidence that the formula for pseudaconine deduced from Wright's formula for pseudaconitine, namely, $C_{23}H_{38}NO_8$ differs by one molecule of water from the formula which Freund has suggested for aconine ($C_{25}H_{41}NO_9$). But, as we have elsewhere pointed out, Freund's new formulæ for aconitine and its derivatives cannot at present be accepted as proved,

Pharmaceutical Society, by Mr. H. T. Durant.

G. I. C. P. O.—No. 1185 R. & A.—25-6-98—2,200—J. E. F.

All communications regarding THE AGRICULTURAL LEDGER should be addressed to the Editor, Dr. George Watt, Reporter on Economic Products to the Government of India, Calcutta.

The objects of this publication (as already stated), are to gradually develop and perfect our knowledge of Indian Agricultural and Economic questions. Contributions or corrections and additions will therefore be most welcome.

In order to preserve a necessary relation to the various Departments of Government, contributions will be classified and numbered under certain series. Thus, for example, papers on Veterinary subjects will be registered under the Veterinary Series, those on Forestry in the Forest Series. Papers of more direct Agricultural or Industrial interest will be grouped according as the products dealt with belong to the Vegetable or Animal Kingdom. In a like manner, contributions on Mineral and Metallic subjects will be registered under the Mineral Series.

This sheet and the title-page may be removed when the subject-matter is filed in its proper place, according to the letter and number shown at the bottom of each page.

NOTICE.

Future issues of this publication placed under either the "Special Veterinary" or "Special Forest Series" will not be included in the annual enumeration. Such papers are printed for Departmental purposes Their unfortunate inclusion in the system of annual numbering has led recipients of the ordinary issues to think their sets incomplete.

The following pamphlets have already appeared as Special issues, and have not accordingly been furnished to the public

1894 . . .	Nos. 8, 9, 10, 11, 13 and 15.
1896 . . .	No 8.

THE

AGRICULTURAL LEDGER.

1898—No. 4.

CASTANEA VULGARIS.

(SWEET OR SPANISH CHESTNUT.)

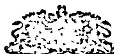
[*DICTIONARY OF ECONOMIC PRODUCTS, Vol. II., C. 808-11.*]

THE SPANISH CHESTNUT.

Note on the Cultivation of the Spanish Chestnut in the Himálayas.
By SIR E. C. BUCK, KT., C.S.I.

Other DICTIONARY articles that may be consulted:

Famine Foods, *Vol. III.*, F. 32.
Nuts, *Vol. V.*, N. 177.



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The objects of THE AGRICULTURAL LEDGER are :—

(1) To provide information connected with agriculture or with economic products in a form which will admit of its ready transfer to ledgers,

(2) To secure the maintenance of uniform ledgers (on the plan of the Dictionary) in all offices concerned in agricultural subjects throughout India, so that references to ledger entries made in any report or publication may be readily utilised in all offices where ledgers are kept,

(3) To admit of the circulation, in convenient form, of information on any subject connected with agriculture or economic products to officials or other persons interested therein;

(4) To secure a connection between all papers of interest published on subjects relating to economic products and the official Dictionary of Economic Products. With this object the information published in these ledgers will uniformly be given under the name and number of the Dictionary article which they more especially amplify. When the subject dealt with has not been taken up in the Dictionary, the position it very possibly would occupy in future issues of that work will be assigned to it.

THE

AGRICULTURAL LEDGER.

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THE SPANISH CHESTNUT.

Note on the Cultivation of the Spanish Chestnut in the Himálayas.
By SIR E. C. BUCK, KT., C.S.I.

1. This note will be divided under the following heads:—

I.—The value of chestnuts as a supplementary food-supply in the Himálayas.

II.—The history of past operations in the North-West Provinces and the Panjab.

III.—Cultivation in Spain and Italy.

IV.—Suggestions for future action.

I.—Value of Chestnut as a Food-supply.

2. So long ago as 1838 Dr. J. Forbes Royle urged the cultivation of the chestnut in a letter to the Directors of the Honourable East India Company in the following words:—"The common Spanish chestnut," he wrote, "seems well suited to Northern India and the Himálayas, and would yield an additional article of food to the inhabitants of the mountains who are sometimes forced to subsist upon acorns and bitter horse chestnuts." I.—VALUE OF CHESTNU AS A FOOD-SUPPLY.

CASTANEA vulgaris. | The Spanish Chestnut.

I.—VALUE of CHESTNUT as a FOOD-SUPPLY.

3. That the inhabitants of the Himálayas at any material distance from the plains often suffer severely in seasons of deficient outturn is well known. The main reason is the difficulty and cost of importing food-grains from below, especially in years when scarcity is common to the plains and the hills. Perhaps the Kumaonis of the North-West Provinces are better off (in view of their supplementary cultivation in the "Bhabur" at the foot of the hills and of their general comparative prosperity) than the inhabitants of Native States behind Mussoorie and Simla, but that even they do suffer to a material extent is indicated in the recent "Narrative" published by the North-West Provinces Government on the famine of 1896-97, in which it is remarked that "in the Himálayan districts with a population fast growing in density and harvests entirely dependent on a rainfall, which is not stable, imports of grain have of late years been often necessary to prevent or alleviate distress." A suggestion to construct another railway to the foot of the hills follows. But it may be noted that even when grain has been brought to the foot of the mountain ranges the labour and cost of carrying it over hill-roads into the interior is enormous.

Need which exists in the Himalayas for a supplementary food-supply.

4. It is still the case that in seasons (which as shown above often occur) of local distress the hill-people eat the unpalatable and unwholesome horse chestnut and other wild fruits. Indeed, in many parts of the hills, they partially subsist on wild fruits in every year. In Stewart's report on Bijnor (*page 679, Kumaon Gazetteer*), he remarks that "Hill-men eat greedily all kinds of fruits, both cultivated and wild, and very rarely allow either to ripen thoroughly. The number of wild fruits and berries is very large, and the supply lasts from April to October, forming a welcome, though not perhaps always a healthy, addition to their food."

Wild fruits relished by hill tribes.

5. The value of the Spanish chestnut as a supplementary food-supply in tracts where it can be successfully grown has been thoroughly established in the mountainous regions of South-West Europe. The gross annual outturn of chestnut fruit in the hills of Italy is estimated at 360,000 tons (*India Office Reports, 1892, page 35*) or in Indian weight about 10 millions of maunds. This quantity at 4℔ a head (see page 9) would feed one million of persons for 100 days without other food. Production in Spain is equally important.

Spanish Chestnut as an additional food substance in Europe.

A large proportion of the nuts are used as food:— *I—VALUE of CHESTNUT as a FOOD-SUPPLY.*

(1) in the form of flour, for making into cakes (something like the Indian chapâti) either alone or mixed with cereal flours;

(2) for making soup;

(3) roasted or boiled whole.

It is not the case that the chestnut is preferred as a staple food to cereals But it is enjoyed as an ordinary article of diet even by the better classes in South Europe and is imported as a delicacy to North Europe, while the lower classes of the mountain countries do actually subsist on it largely Thus, in the province of Asturias (Spain) (*India Office Reports, 1892, page 25*), it is stated that "in many districts where the crop of grain is poor and uncertain on account of the climate, the chestnut is considered as the basis of the food-supply in its season, which in some localities lasts four months and replaces maize head, beans, and potatoes. (The outturn of nuts in this province is about 1½ millions of maunds.) In Cuneo (Piedmont) *40 per cent., in Liguria two-thirds, in Piacenza 60 per cent., in* Arezzo (Tuscany) two-thirds of the yield is reported to be used locally as food. In these and in other districts the price paid for chestnuts to be exported to other countries is sufficiently large to induce the inhabitants to part with a considerable portion of their crop. But wherever exported it is used, in some form or other, as food. *Cooked in various ways.*

6 Professor Church in recording his analysis of chestnut flour, intimates that "chestnut flour ought to be of easy digestibility, and a suitable children's food, considering that it contains over 40 per cent. of nutritious matters soluble in pure water." According to Parmentier the nut contains as much nutritive matter as cereals. *Appendix II., page 17.*

7. The facts above noted seem to justify the presumption that the Spanish chestnut will, if it can be successfully and extensively cultivated in the Himálayas, afford a supplementary food-supply of material value to the hill-people even in ordinary years as well as in seasons of scarcity. And it is a satisfactory circumstance indicated by experimental cultivation near Simla that the yield of sound fruit is better in years of light rainfall than in years of abundant rain. This observation is confirmed by the reports from the Continent where the minimum yield is in "cold and rainy seasons." If then *Advantages of successful cultivation in the Himalayas.* *Yield of fruit greatest in years of light rainfall.* *Conf. page 9, para. 21*

CASTANEA vulgaris.	The Spanish Chestnut.

II - HISTORY of PAST OPERATIONS

the chestnut does succeed in the Indian Hills, it will yield its largest supply of food in years when it is most wanted. The reasons why light rainfall is advantageous are given later on.

II.—History of Past Operations.

8. Experimental cultivation of the chestnut in the Himálayas was for the first time taken up seriously about 25 years ago. An account of the action taken will be found in a report (*Agricultural Ledger No. 15 of 1894*) on Himálayan fruit culture by Mr. Smythies, of the Forest Department. Briefly, it may be stated that the Forest Department after considerable difficulties succeeded in bringing over seeds from Europe in 1873, and three or four years later at the instance of Sir Henry Ramsay and under my own direction, the North-West Provinces Agricultural Department imported after several failures large quantities of sound seed and grafted trees.* The Forest Department plantations were raised at the Ranikhet fruit garden at an elevation of about 6,000 to 6,400 feet, and those of the Agricultural Department at about 7,000 feet at Muktesar between Naini Tal and Almora. Both gardens were eventually placed under the direction of Mr. Craw, a Scotch tea-planter near Ranikhet, who, having had a training as a professional gardener, was very successful in rearing the trees.

Operations at Ranikhet

Muktesar.

Distribution of saplings.

9. From both gardens distribution of young trees has been made to the owners of private orchards, to other Divisions of the Forest Department, and to Government gardens, about 2,300 having been sent out from Ranikhet and 600 from Muktesar. Those supplied in the earlier years were grafted trees, but of late years seedlings have been distributed. The point is of importance, since, as will be indicated later on, only grafted trees bear large fruit. The general elevation at which plantations have been formed has been from 5,500 to 7,500 feet. There has on the whole been more failure than success in results. Crops have been small, and a large proportion of the nuts have been hollow shells. The reasons of failure will be discussed presently, but among them the most prominent are that the elevation has been too high, the aspect has often been unfavourable, the number of trees has some-

Plantations, general elevation.

* *Note.*—In the event of future importations being required, information as to the most successful method of packing seeds will be found in the Annual Reports of the Forest Department of 1873, *et seq.*

times been too small to ensure fertilisation, and the rains have occasionally interfered with fecundation at the critical time. That the causes of failure can be removed or considerably modified, is probable. In exceptional cases success has been obtained, and the conditions under which success has occurred can be repeated over large areas available for chestnut plantation, while, on the other hand, conditions of failure can be avoided. II.—HISTORY of PAST OPERATIONS.

I myself made many experiments at various elevations and aspects near Simla between 1883 and 1895. The most satisfactory results were obtained at Mr. Goad's gardens at 4,500 feet with a north aspect. Baskets of excellent fruit from this garden were often exhibited at the Simla horticultural shows. I found also good fruit at 5,000 to 6,000 feet in private orchards in the Kulu Valley where summer rainfall is light and the land is protected by high mountain walls on either side, though from two gardens the shrivelling of the fruit was reported. Similar results were obtained in the Forest plantations above the Sutlej Valley, where again the summer rainfall is light. Here the elevation was from 6,200 to 7,500 feet, the best results being attained at the lowest elevations. Experiments in Simla neighbourhood. Kulu Valley. Sutlej Valley.

10. There are now in the country a large number of trees, grafted and ungrafted, bearing enough fruit for the unlimited expansion during the next few years of the stock of seedlings, and there are also a sufficient number of grafted trees bearing a fair quantity of sound fruit to admit of the grafting from them of any percentage of seedlings that is wished. The questions that have to be decided, *viz.*, suitable sites for plantations, the best elevation and aspect, the extent to which trees should be grafted, and the varieties of the Spanish chestnut which should be encouraged, will be most conveniently discussed after dealing with the reports which have been obtained from Europe. Abundance of stock. Location of sites, elevation, aspect, etc.

III.—Cultivation in Spain and Italy.

III.—CULTIVATION in SPAIN and ITALY.

11. In 1890, I submitted a request to the India Office that information might be obtained from our Consuls in Spain and Italy or from other sources as to the conditions under which chestnuts were grown and utilised as food in those countries In 1892 the reports*

* Copies may be obtained from the Imperial Department of Revenue and Agriculture.

CASTANEA vulgaris. — The Spanish Chestnut.

III.—CULTIVATION in SPAIN and ITALY.

with a review by Sir George Birdwood were communicated to the Government of India. A summary of the information received is given in the appendices to this note, but a few of the leading and most important facts are detailed in the following section.

Catalonia.

12 The following remarks taken from the report received from Catalonia (Reports, page 28), appear applicable to the Himálayas: "Chestnut trees," it is written, "are of very rapid growth in mountain *districts which are not generally well adapted for* any other sort of culture, and as they require scarcely any care whatever and are certain to yield their annual crop, the increase of their cultivation is easily accounted for."

Asturias.

13. In the report from Asturias (page 25) it is stated that the crop is best in years of warmth and light rainfall. But it is in the report from Catalonia (page 30) that the statement is made which suggests the main reason why so much hollow and shrivelled fruit has been gathered on the Himálayan trees. "Chestnuts," it is said, "blossom in June, and heavy rains in the latter days of June when fecundation takes place may injure them." Now high elevations are in the Himálayas much more exposed to heavy rain in June than low elevations, and if the presumption is correct that for other reasons elevations below 5,000 feet are preferable, it may be found that the percentage of hollow fruit will be much diminished when the trees are grown at the lower levels

Cultivation should be practised at elevations below 5,000 feet.

14 The chestnut tree is stated to be grown for the production of—

Products of the tree.

(1) Fruit for local consumption as an article of diet.
(2) Fruit for export
(3) Timber.
(4) Hoops and staves
(5) Leaves for manure.

Varieties (a) for local consumption, (b) for export.

15. The varieties used for local consumption are not, as a rule, those used for export. The large nut, familiarly known as the "Marron," is only "eaten and sold fresh," "the other qualities" which form the larger part of the yield, are ground into flour, etc., (page 18 (Tuscany). The question arises whether the grafts which we have imported are not too exclusively the "Marron" variety, and if so, the circumstance would perhaps partly account for the difficulty which has been experienced in this country in keeping the

fruit in good condition, for from all gardens it has been reported that the fruit "spoils" after a few days. The best quality (in Spain) is said to be "a round nut from grafted trees having a separate nut in each shell, nearly spherical," whereas "inferior qualities generally produce three nuts under one cover" (page 23) The Himálayan fruit I have seen either resembles the Marron or the inferior fruit above described—though, perhaps, the latter has been taken from ungrafted trees.

III.—CULTIVATION in SPAIN and ITALY.

The best fruit described

16. Trees grown for fruit are almost always grafted. The fruit from ungrafted trees is in some of the Italian districts only used to feed pigs, but in the report from Catalonia (page 29) the important statement is made that the fruit from ungrafted forest trees, though small and late, is very abundant and by no means inferior in its nourishing qualities to others and is even sweeter. The main reasons why grafted trees are preferred are that the fruit is earlier, of larger size and more readily saleable.

Difference between *fruit from* grafted and ungrafted trees.

17. The elevation preferred for grafted trees is from 1,500 to 2,000 feet with a northern aspect (pages 17 to 27) An altitude of 3,000 feet hinders perfect development, "as also the accumulation of snow" (page 35). The maximum altitude in North Italy is about 2,500 feet. Extreme dryness is prejudicial, and (in Catalonia) "scarcely a tree is found on the southern slopes, where, probably, the direct action of the sun's rays combines to deprive the soil of whatever moisture it might contain" (page 27). Early or late frost is prejudicial. The soil should be light and sandy.

Best elevation for grafted trees.

The tree flourishes in a moist but light and sandy soil.

18. These facts indicate that careful experiments are needed to ascertain the right elevations for grafted trees in different parts of the Himalayas, and confirm the presumption that our plantations have been hitherto placed too high, generally at 5,500 feet and upwards Trees planted for timber may, however, be successfully grown at somewhat higher elevations, and for coppicing are sometimes "relegated to localities where too low temperatures prevent the fruit from maturing" (page 31). The best temperature for fruit is said to be a medium heat of 55° F., ranging between 14° and 92°, and for timber of 48° F., ranging between 5° and 77° in the shade.

Further experiments necessary.

Suggestions.

19. The yield of a chestnut tree varies of course with the conditions under which it is grown. *The following estimate is given in the* report from Asturias (Spain) substituting Indian for Spanish weights.

Yield in Europe.

CASTANEA vulgaris	The Spanish Chestnut.

III.—CULTIVATION in SPAIN and ITALY.

About 32 trees are planted in an acre. The produce of a tree is about 10 seers and the produce of an acre about 8 maunds. But this estimate assumes the youngest trees to be 12 to 15 years old and the oldest "several centuries" (page 24). Another estimate from Catalonia gives the produce of a tree over 25 years in full bearing as three-fourths of a maund (page 31), while from Tuscany the average yield in seven years from about a million of acres is given as between 7 and 8 millions of maunds (page 17). (This nearly agrees with the Asturias estimate.)

V.—SUGGESTIONS for FURTHER ACTION.

IV.—*Suggestions for Further Action.*

Experimental plantations.

Size important for fertilisation.

20. The distribution of trees in small quantities to isolated gardens or cultivators' holdings is not, at present, an important object. It would seem desirable for the next few years to make experimental plantations under expert direction at different elevations and in different localities, in order to ascertain positively what are the most suitable conditions of soil, elevation, and climate for the successful cultivation of the tree in the Himálayas. The plantation should be large in order to give every facility for fertilisation, as there is reason to believe that where only a few trees are in one neighbourhood pollen is not carried from one tree to another in sufficient quantities.

Value of timber stated to recoup for small yield of fruit.

21. Such experiments could perhaps be most usefully carried out by the Forest Department. In view of the fact that chestnut timber is valuable there need not, as I have been told by a Forest officer (Mr. Hearle, Deputy Conservator, Naini Tal), be any loss, even if the fruit turns out to be of no great importance. In some cases, however, it may be hoped that the fruit itself will, when the trees have arrived at maturity, 20 or 30 years hence, be of material value as a food for the neighbourhood.

Seedlings available.

22. There are now some 3,000 seedlings at the Ranikhet garden which could, some grafted and some ungrafted, be thus utilised. In making grafts the older trees which are found to bear single kernels and compact nuts (most in accordance with the description of paragraph 15) should, perhaps, be chosen to supply graft wood. There are probably other seedlings available at the Simla gardens or in the forests beyond Simla which could be similarly utilised.

23. Considerable quantities of seed from the older trees planted 20 to 25 years ago are now annually available. If the Forest Depart-

ment would permit the seed to be sown in nurseries every year large stocks could be annually raised. In consideration, however, of the doubt which exists whether we have imported into India grafted trees of the kind which are explained in paragraph 15 to be the most useful for food purposes, it might be desirable to obtain, through the India Office or otherwise, a few more grafted plants in Wardian cases from Spain. Otherwise there is plenty of material to work with.

V.—SUGGESTIONS for FURTHER ACTION.

See Appendix I.

24. The evidence from Europe and in India itself points to the desirability of planting between 3,000 and 5,000 feet rather than as hitherto between 5,000 and 7,000 feet. The best elevation can only be ascertained by careful experiment and may differ in different parts of the Himálayas. There seems, however, to be no doubt as to aspect. It must be north rather than south, and north-east rather than north-west. Localities of heavy rain should be avoided. If, as seems probable, an elevation of 4,000 feet is not unsuitable, the lowness of altitude will in itself ensure a lighter rain than that which occurs at higher altitudes, especially as the earlier rains are believed to be heavier on southern than northern slopes. As already indicated, heavy rain in June interferes with fecundation, but much wet later on seems also to have a tendency to rot the ripening fruit. It is, perhaps, for these two reasons that years of scanty rain appear to result in better crops of fruit. If the correctness of this presumption can be established, the circumstance is in favour of the belief that the fruit will be a valuable food-supply in years of comparative drought and scarcity. These arguments do not, however, much affect experiments in those regions of the hills, such as Kulu and Kashmir, which are beyond the influence of heavy summer rain.

Elevation required for successful growth.

Aspect.

Avoid heavy rainfall.

Conf., page 3, para. 7.

25. It would seem desirable that, in order to ascertain with more certainty what is the actual effect of differing elevations and rainfalls on the fertility of chestnut trees in the Himálayas, registers should be kept of the average weight and condition of the crop of various plantations. Some information of the kind might also be annually obtained from planters who have a sufficient number of chestnut trees in their orchards to give value to the observations.

Registers of weight and condition of crop recommended.

26. It is possible that the best land which could be taken up for chestnuts would be the belts which lie just at the foot of large forests and just above the gentler slopes of cultivation including perhaps a few fields. Only such fields would be used as are seldom cropped or

Appendix I, page 10

CASTANEA vulgaris.	The Spanish Chestnut.

IV.—SUGGESTIONS for FURTHER ACTION.

Leaves afford manure.

are too steep for really successful cereal agriculture. The fact that the leaves give a useful manure is also in favour of plantations near cultivated land.

Concluding remarks.

27. It would seem to be premature to press the cultivation of the tree at present on the agricultural population, although exception might be made in the case of intelligent proprietors with large estates or holdings, especially in those instances where they already have formed orchards of fruit trees. But attention may be drawn to the circumstance that a Pictorial Lesson Sheet on the chestnut tree and its uses was some time ago prepared (in the Imperial Office of Revenue and Agriculture), which might, with such additions as may be considered necessary, be utilised in Himálayan schools, translated, if wished, into hill dialects Familiarity with the fact that the chestnut can be used in various ways as food may prove to be of eventual service.

APPENDIX I.

APPENDIX I.

Synopsis of Reports from Italy and Spain.

The headings adopted below are mainly taken from an account of the chestnut tree included in his "Manual of Forestry" by Dr. Schlich, formerly Inspector General of Forests and now Professor of Forestry at Cooper's Hill. The reports referred to are contained in Sir George Birdwood's pamphlet. The various methods of preparing the fruit for food are summarised in Appendix II. The utility of the chestnut for food is not referred to in Appendix I.

Schlich.

Utility.—Yields a fairly hard, moderately heavy timber, specific gravity air dried =·66; splits well; durable; used for building; in carpentry staves for wine casks, line stakes, hop poles. Not a very good firewood but charcoal. Much appreciated by blacksmiths. Bark used for tanning.

Asturias (Spain).

Timber for building; leaves to enrich soil; wild mountain species gives better wood.

Catalonia (Spain).

Trees cut down (coppiced) throw out branches 20 to 30 feet high in four or five years, diameter at foot 2 to 4 inches; cut into two or more strips for hoops of casks. For staves only three or four branches allowed to grow for 20 to 25 years. Compete favourably with American oak staves For timber only one trunk. Excellent timber; *neither warps nor rots; resists dampness perfectly; does not*

The Spanish Chestnut. (*Sir E. C. Buck*) CASTANEA vulgaris.

admit of fine polish. Saw-dust and refuse profitably distilled containing abundant tar and other utilisable substances. APPENDIX I.

Elevation and Aspect.—A tree of the lower hills and mountains preferring northern and eastern aspects. Schlich.

400 to 800 metres. N. Italy.

Does not generally flourish above 1,000 metres. Asturias.

Chestnuts lie between cultivated land and oak forests. Asturias.

Only on northern slopes where cool breezes, springs and rivulets prevail; at 2,000 to 3,000 feet. Catalonia.

Not higher than 800 metres, in valleys. Italy.

Climate.—Mild. Tree is tender against early and late frost; light demanding but less than oak; *stands shade in youth and thrives* under Scotch pine Storm firm. Schlich.

Require damp atmosphere, renovated by cool moist currents of air. Excessive dampness of ground injurious. Low temperature tends to promote vertical growth at expense of fruit, but great cold makes them stunted. Catalonia.

Soil.—Likes a deep, porous, fresh and fertile soil. Can grow in rather dry soil if deep, but avoids wet. Loamy sand suits it best; does not like heavy or calcareous soils. Schlich.

Sandy, light and porous Clayey, stoney and compact grounds *unfit, on slatey formations not a single tree is found. Not* very exacting as to chemical conditions of soil. Development depends infinitely more on situation, hydrometric state of atmosphere, temperature, and physical conditions of soil. Soil in Catalonia is detritus of adjoining granite rocks, so loose and incoherent that it falls in separate grains, generally composed of silex orthose, *felspar and* mica. Catalonia.

Shape and Development.—Straight stem branching at moderate height. Root system deep growing like oak. Lower than oak, but attains very large diameter; reaches age of more than 500 years. Schlich.

Reproductive Power.—Comes into full bearing at about 50 years, full seed every two or three years; reproductive power from stool very great even at 100 years old. Schlich.

Grafted trees in full bearing at 20 to 25 years. Catalonia.

Sylvicultural System.—Does well with beech and oak as high forest, and requires under-planting grown pure or mixed as copp ce. Schlich.

CASTANEA vulgaris	The Spanish Chestnut.

APPENDIX I. High forest generally treated under rotation of 100 years, coppice 3 to 30 (see also above under *Utility*, page 10).

Schlich. *Formation of Wood.*—Direct sowing is done, but chiefly planting. Nuts retain germinating power for about six months. Sow in spring as autumn sowings are eaten by mice; not too early as seedlings are tender against late frosts. Cover with about $1\frac{1}{2}$ inches of soil; germination in five or six weeks.

Catalonia. Trees for fruit should be young, healthy and well-rooted, transplanted generally from sites of natural production. If such not obtainable, sow in loose ground without manure. Sow while still tender not more than a month after fall.

Sir E. Buck. [My experience in India favours the sowing of fruit as soon as possible after being gathered—in boxes protected from the climate, charcoal dust and sand being mixed with light garden soil. But the forest officers have now gained further experience and will no doubt develop a safe system of sowing.]

Schlich. *Nurseries*—Sowings in drills, or nuts placed flush in rows and covered with $1\frac{1}{2}$ inches of soil. Seedlings pricked out when a year old and put out after two years more; frequently older plants used pricked out a second time stand pruning well both on crowns and roots. Young chestnuts must be protected against early and late frosts

Catalonia *Cultivation for Fruit.*—Slips when planted do not thrive well, and, consequently, all forests destined for the production of fruit are made up of young, healthy, and well-rooted trees, which are transplanted usually from the sites where they grow abundantly. If such trees are not easily obtainable, it is best to sow the seeds in loose ground, without manure, in a nursery, and, if possible, where they can be irrigated. The plants are kept in the nursery for four or five years, or till they are to be transplanted.

Raising plants from seed. Plantations may be made directly also by sowing the seeds, the only drawback to doing this being the extra time required for the forest to yield any profit.

Transplanting. Almost all the seeds when sown germinate, and, consequently, they may be sown close to each other, and, after growth, the least healthy plants separated and the best left at convenient distances from each other.

The proper time for sowing is whilst the fruit is still tender, and when not more than a month has elapsed since their fall from the trees In Gerona the best period for sowing is from December to January. Period for sowing.

If they are to be sown later, it is then necessary to preserve the chestnuts in impermeable subterranean granaries ("silos") covered with sand; and when taken out of the "silo" the rotten chestnuts are to be separated from the sound ones which is effected by submerging them in water, when the decayed fruit will float When necessary to preserve in silos.

Anyhow they should be sown closer to each other than usual, as many of them may not germinate.

The depth at which they should be sown is from four to eight inches from the surface.

Trees grown from seeds are transplanted in the usual manner, and in this district they are transplanted from November till February and at a distance of from 9 to 15 yards from each other, according to the development which it may be inferred the upper part of the tree is likely to attain, and which will be in direct ratio to the fertility of the soil. Transplanting.

In very fertile soils their closer proximity favours only the vertical growth of the plant at the expense of its fertility, but, in less favourable ground, as they develop less vigorously, more may be conveniently planted. Planting in fertile and other soils.

The trees can be transplanted at almost any age, as they take root easily, but their diameter should never exceed a couple of inches, in order that they may be safely grafted, if necessary.

The healthier and better developed trees are therefore selected, and all their branches cut off leaving only the stock.

Though the soil needs no preparation generally, if it has been previously utilised as a vineyard or as pasture land, the same culture is continued during four or five years till the young trees are sufficiently developed If the soil has never before been cultivated, it is broken up and utilised during four or five years for growing wheat, or potatoes, in order to cover the cost of the plantation. Of course, the ground is in this case broken up before the trees are planted. Remarks on tillage.

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APPENDIX I.

an almost necessary operation; as if this is not done the fruit will not be of the required quality for its sale.

Grafting:

Grafting is effected as soon as the trees have taken root, or as soon as possible, for by doing so their period of yielding fruit is hastened.

When not practised fruit is small in size and late in appearing.

There are many chestnut tree forests of great age, however, that have never been grafted, and consequently, the fruit these trees bear is of small size and late, though very abundant, and by no means inferior in its nourishing properties to the others; but as the qualities most in demand are early chestnuts and chestnuts of large size, grafting with the varieties which possess these two properties is at present the prevailing custom.

Varieties.

When these conditions are not specially required, grafting is, perhaps, unnecessary. There appear to be from 12 to 15 varieties of chestnut trees, but it is not known, with any degree of certainty, how many of these varieties flourish within the limits of the province of Gerona. The fruit of all these varieties is pretty much the same, and they are specially distinguishable from each other only through the difference in the period in which their fruit is matured, and also by the difference in their size. Only two other observations are worthy of statement. That the small fruit is generally sweeter than that of a larger size, and that the chestnut trees which yield late fruit, yield them nevertheless very abundantly.

Small size fruit usually sweet. Late fruit most abundant.

This excess of production is, however, of little avail to the owners in the localities where chestnuts are produced; for as they are sold by measure and not by weight, and in equal measures small chestnuts will naturally weigh more than larger ones the advantage they might obtain is more than counterbalanced. In conclusion, it may be safely asserted that there is really very little difference between all the varieties of chestnuts produced in Catalonia.

Difference between varieties not great.

Remarks on grafting.

The best method of grafting is by means of twigs (canutillos). The trees from which these twigs or slips are to be cut are pruned during winter, in order that tender shoots may be obtained from them in the ensuing summer. These twigs should have only one bud. The best period for grafting is from July to August. The stock which is to be grafted is to be cut to the height of about four feet from the ground, or as short as possible, and on the upper part the slip, without any leaves to it, is to be attached. It is well to

state that at the time of grafting the stock which is to be grafted should not be pruned, as this tends to increase prejudicially the number of its shoots. This should be effected in the following year, when the exuberant shoots under the grafting can be easily detached with the hand. APPENDIX I.

No other attention or care is requisite for the cultivation of these trees than what has been stated, for when the grafted slips are thriving even pruning is unnecessary. The ground under these trees is kept perfectly free from all other vegetation excepting fine grass naturally, and the soil requires neither manure nor culture of any sort whatever. Grafted trees require little attention.

APPENDIX II.

APPENDIX II

Methods of Preparing Chestnuts for Food.

Fruit should be allowed to drop from the trees not beaten down. Gathering.

Marrons are always consumed fresh. Other qualities (the larger portion of yield) are ground into flour after having been dried by exposure to a slow wood fire for 30 to 40 days. The operation is carried out in small buildings constructed of rough stones (*metati*), page 18 (Tuscany). Drying and grinding into flour.

Preparation of Fruit for Grinding.—To remove the husks before grinding, the most general system in Tuscany appears to be to place a certain quantity of chestnuts, while still hot, in a long sack, the ends of which are held by two men standing across a heavy block of wood, on which the sack with its contents is violently beaten. In some districts (as in the Casentina) the chestnuts are heaped in tubs and trodden under foot by men wearing wooden clogs (zoccoli), the soles of which are fitted with iron spikes, or, as in the Pistoia mountains, pounded with poles fitted with a serrated iron head. The final cleansing of the chestnuts, an operation termed "sventolatura" is performed by the women. While this operation is going on, the young men often dance and sing round the "metati" Preparation for grinding. Sventolatura or cleansing.

Farina dolce or Chestnut Flour.—The chestnut flour is termed "farina dolce," or sweet, in contradistinction to wheat or maize flour, but, it is rarely used as a sole article of diet, except by the poorest peasants in the mountains who are unable to obtain any other kind of food. Chestnut flour (*farina dolce*).

CASTANEA vulgaris. | The Spanish Chestnut.

APPENDIX II. Manner of cooking *Conf., p. 17.*

Modes in which Chestnuts are Cooked.—The flour, with the addition only of water and occasionally a little salt, is cooked in various simple ways, as "polenta," a thick porridge, "farinata," a soup of less consistency than the "polenta" or "necci," thin round cakes baked, between two flat hot stones, and to which a special aroma is given by placing a dried chestnut leaf above and below the paste while baking. If the above formed the sole article of diet, it is estimated that a daily ration of one kilogram of flour, converted into about $1\frac{1}{2}$ kilograms* of "polenta" or $1\frac{1}{4}$ kilograms of "necci," might suffice for an adult male. These are, however, usually alternated with "polenta," made of Indian corn, or wheat and rye bread, in which case the amount of chestnut flour consumed is reduced to one-third or one-fourth, according to circumstances. The subsidiary articles of food, more or less in use, are cheese, "ricotta," stockfish, pickled herrings and sardines, sausages, beans, potatoes, and, on high occasions only, unless the peasant is in easy circumstances, pork. Other meat is not often consumed. The usual condiments are oil and lard. But little wine is drunk in the mountain districts; only occasionally, in seasons of hard work, a glass of spirits. The spring water is, however, excellent and abundant. In the less elevated zone the peasant reserves for his own use the "vinello" after the wine has been made.

Dried Chestnuts.

Dried chestnuts are cooked in water or milk and are eaten as a soup at the evening meal (page 20, Piedmont).

Form part of common food of the peasantry.

Form part of the daily dietary of the peasantry peeled, cooked, and eaten with skim milk. Also often dried, placed on a frame under the kitchen chimneys when they acquire a sweet savour and are easily husked by pressure with the fingers. In this state sometimes eaten in soup instead of beans mixed with turnips. Indian corn meal flavoured with butter and bacon not ground but placed whole in soup (page 20, Venetia, Udine).

Chestnut porridge, cakes, bread.

Used for porridge and cakes, and in some parts bread made from chestnuts is common among the peasants and even the better classes. During two months after crop is gathered consumption is estimated at about 4lb per head, the chestnut forming the exclusive article of food among the peasantry. In some localities it lasts four months (page 23, Asturias).

* The kilogram = 2·2 lbs. Av —*Ed*

APPENDIX II.

Conf., p. 16.

Mode of Cooking and Curing.—When treating of the mode of cooking, the difference between the freshly gathered nuts and the dried and cured must be borne in mind. The latter are gathered and dried in airy storehouses, or on the open hearth before the fire in the peasant's hut, under which operation they shrink up, loose their outer skin, and become extraordinarily hard and yellow

Pilongas.—They are then called "*Pilongas,*" and formerly were pounded into flour and mixed with a species of mild maize or millet, for bread making but the importation and cultivation of maize proper have now replaced this mode of nutriment. Fresh nuts do not require any oily substance for cooking, simply peeled and boiled with a little salt, they make a very nutritious dish, and in soups, stews, or with beans, they are a good and agreeable substitute for potatoes They are also roasted in their skins as a dessert.

Different Dishes made with Pilongas—The nuts cured and stored called "*Pilongas*" boiled in water with a little salt, and eaten with milk, the usual Lent dish in Asturias, form an acceptable meal even to people accustomed to good living. Eaten alone in milk or mixed with honey they also make a capital plate, and taste like "Marrons glacés" used here in winter. In some places the nuts when dried are ground into flour, and made into a kind of porridge like the Italian polenta (page 25).

Professor Church's analysis of Chestnut Flour is the following:—

Conf., p. 3.

Analysis of Chestnut Flour.

Moisture	14·0
Oil or fat	2·0
Proteids	8·5
Starch	29·2
Dextrin and soluble starch	22·9
Sugar	17·5
Cellulose, etc.	3·3
Ash	2·6
	100·0

"The cakes were found to contain only 6·2 per cent. of proteids, with 3·4 per cent. of ash. The large amount of dextrin is due to the high temperature to which the chestnuts are subjected in the process of drying."

C. 808-11.

G. I. C. P. O.—No. 48 R. & A.—6-7-98.—2,225—G. R.

All communications regarding THE AGRICULTURAL LEDGER should be addressed to the Editor, Dr. George Watt, Reporter on Economic Products to the Government of India, Calcutta.

The objects of this publication (as already stated) are to gradually develop and perfect our knowledge of Indian Agricultural and Economic questions. Contributions or corrections and additions will therefore be most welcome.

In order to preserve a necessary relation to the various Departments of Government, contributions will be classified and numbered under certain series. Thus, for example, papers on Veterinary subjects will be registered under the Veterinary Series; those on Forestry, in the Forest Series. Papers of more direct Agricultural or Industrial interest will be grouped according as the products dealt with belong to the Vegetable or Animal Kingdom. In a like manner, contributions on Mineral and Metallic subjects will be registered under the Mineral Series.

This sheet and the title-page may be removed when the subject-matter is filed in its proper place, according to the letter and number shown at the bottom of each page.

NOTICE.

Future issues of this publication placed under either the "Special Veterinary" or "Special Forest Series" will not be included in the annual enumeration. Such papers are printed for Departmental purposes. Their unfortunate inclusion in the system of annual numbering has led recipients of the ordinary issues to think their sets incomplete.

The following pamphlets have already appeared as Special issues, and have not accordingly been furnished to the public.

1894 . . . Nos. 8, 9, 10, 11, 13 and 15.
1896 . . . No. 8.

THE

AGRICULTURAL LEDGER.

1898—No. 5.

OXEN.

(CATTLE DISEASES.)

[*DICTIONARY OF ECONOMIC PRODUCTS, Vol. V., O. 590-94.*]

PROFESSOR KOCH'S METHODS OF IMMUNISING CATTLE AGAINST RINDERPEST.

Reports by DR. A. LINGARD, *Imperial Bacteriologist to the Government of India,* VETERINARY-LIEUTENANT F. S. H. BALDREY, *Assistant Principal, Bombay Veterinary College,* VETERINARY-CAPTAIN W. R. HAGGER, *Principal, Ajmere Veterinary School,* VETERINARY-CAPTAIN H. T. PEASE, *Principal, Veterinary College, Lahore,* VETERINARY-CAPTAIN F. RAYMOND, *Superintendent, Civil Veterinary Department, Bengal,* VETERINARY-CAPTAIN G. H. EVANS, *Superintendent, Civil Veterinary Department, Burma.*

Other PAPERS that may be consulted:

Agricultural Ledger, 1894, Nos. 8 (Rinderpest*) and 13 (Cattle Disease*); 1896, No. 8 (Indian Cattle Plague*).

* Special Veterinary Series only.



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PREAMBLE.

Extract from the Proceedings of the Government of India, Department of Revenue and Agriculture,— No. 8/94-8, dated 5th May 1898.

Read—

Letters from the Inspector General, Civil Veterinary Department, Nos. 173—191, 755 C., and 218-114, dated, respectively, the 6th August, 13th November and 29th December 1897, submitting reports by the undermentioned officers on Dr. Koch's methods of immunising cattle against rinderpest.

Reports by Dr. A. Lingard, Imperial Bacteriologist to the Government of India; Veterinary-Lieutenant

O. 590-94.

RESOLUTION of the GOVERNMENT of INDIA.

[illegible] Veteri- ... Hagger, ... erinary-Captain H. T. Pease, Principal, Veterinary College, Lahore; Veterinary-Captain F. Raymond, Superintendent, Civil Veterinary Department, Bengal; Veterinary-Captain G. H. Evans, Superintendent, Civil Veterinary Department, Burma.

RESOLUTION.

When Professor Koch, the eminent Bacteriologist, visited India in the summer of 1897, he expressed his willingness to demonstrate the methods of immunising cattle against rinderpest, which he had practised during his investigations into the disease in South Africa. The Government of India gladly availed themselves of Professor Koch's generous offer, and arranged with Local Governments that the Imperial Bacteriologist and officers of the Civil Veterinary Department should attend the demonstrations which were to be carried out at the Bacteriological Laboratory at Muktesar in the North-Western Provinces. Professor Koch, accompanied by Dr. Lingard and Veterinary-Captain Pease, first visited some villages in the North-Western Provinces, where outbreaks of rinderpest had occurred, for the purpose of procuring material for his experiments, and then went to Muktesar, where he gave complete demonstrations of his system of immunisation.

2. The importance of these demonstrations can hardly be exaggerated in view of the great loss caused annually by rinderpest in India; and Professor Koch has placed at the disposal of the Government of India, in the freest possible manner, and at considerable personal inconvenience, all the results of his knowledge and experience of this most fatal scourge.

3. All the officers present at the demonstrations have submitted reports giving an account of the

RESOLUTION of the GOVERNMENT of INDIA.

methods adopted by Professor Koch, and as these contain many valuable suggestions, it has been decided to publish extracts from them in the Veterinary Series of the Agricultural Ledgers. The Government of India also consider it desirable that the attention of Local Governments should be specially directed to certain points in the reports which are deserving of special notice.

4. The report of the Principal of the Lahore Veterinary College shows that Professor Koch's method could not well be utilised in the case of outbreaks in the districts in view of the fact that his process of immunising takes quite ten days, and that before this time had elapsed an animal exposed to contagion would be likely to contract the disease. This is a matter of no small importance, but it is believed that more practical methods are already being adopted in South Africa, and experiments are now being carried on by the Imperial Bacteriologist which, it is hoped, will result in the discovery of a method more suited to the requirements of this country. But meanwhile the Government of India ask for the hearty co-operation of Local Governments and Administrations in the carrying out of experiments in different parts of the country, more especially in the districts in the plains. The necessity for such experiments is clear, whilst the account of the experiments carried out by Veterinary-Captain Raymond in Bengal shows how much can be done by officers possessing the necessary qualifications. Sindh would also appear to be a favourable field, and the Government of India will be glad if it is found possible to make experiments there. The Government of India feel assured that Local Governments will encourage experiments wherever it is possible to carry them out by properly qualified agency and without the risk of creating new centres of infection.

5. Another point which is of special importance with reference to the hide trade of India is referred

RESOLUTION of the GOVERNMENT of INDIA.

to in the report of the Principal of the Lahore College. Veterinary-Captain Pease shows how hides may be rendered inert, and his recommendations on this subject appear to be well worthy of careful consideration.

Government of Madras.
" Bombay.
" Bengal.
" North-Western Provinces and Oudh.
Government of Punjab.
" Burma.
Chief Commissioner, Central Provinces.
Chief Commissioner, Assam.
" " Coorg.
" " Ajmere-Merwara.
Resident, Hyderabad.

ORDER.—Ordered, that a copy of the above Resolution be forwarded to the Local Governments and Administrations noted in the margin, for information.

Ordered also, that a copy be forwarded to the Inspector General, Civil Veterinary Department, for information.

[True Extract.]

DENZIL IBBETSON,

Secretary to the Government of India.

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1. In accordance with the foregoing Resolution of the Government of India, the following Reports, or Extracts from Reports, are now printed.

2. Dr. Lingard, the Imperial Bacteriologist, reports as follows:—

Immunising Cattle against Rinderpest. | OXEN.

DR. LINGARD'S REPORT.

DR. LINGARD'S REPORT.

In accordance with your deferred telegram, dated Simla, 5th May, 1897, received by me at Jainti, Hathipoda, North-East Bengal, at 5 P.M. on May 9th, 1897, I started for Bombay on the same date at 7 P.M., and arrived on May 16th.

2. On receipt of your letter No. 474—191 M., with instructions, I at once placed myself in direct communication with Professor Koch.

The outcome of our several meetings was that Professor Koch kindly offered to demonstrate the steps of his protective system against rinderpest in cattle, if he might be allowed to obtain the material at the seat of an outbreak of the disease and conduct his demonstrations at Muktesar Laboratory.

3. After having informed you by wire of the Professor's proposals, I followed out your instructions to obtain information concerning outbreaks of rinderpest as near as possible to the Laboratory.

For this purpose I put myself in communication with the Superintendent, Civil Veterinary Department, North-Western Provinces, [illegible] ent in [illegible] arpur). [illegible] Lieu- [illegible]

4. After making the necessary arrangements in Bombay, Professors Koch, Gaffky and Pfeiffer left Bombay with me on the 26th of May and proceeded at once to Lucknow, where we arrived on the 28th. From this station telegrams were despatched to different District Officers, and information received as to the best locality to [illegible] 30th May, in consul- [illegible] we left Lucknow for [illegible] where a rinderpest out- [illegible]

Information having been received by the Deputy Commissioner during the day, concerning cattle disease in the Akbarpur Tehsil, tents and other necessaries were despatched by his orders to Akbarpur to await our arrival on the following morning.

5. On the 31st we proceeded by rail to the above station. The Veterinary Assistant of the district met us there, and informed us that rinderpest was supposed to be present in the villages near Tanda, some 12 miles distant. And after corroborating the same, we made arrangements for leaving the station early on the following morning.

6. *On our arrival at Tanda on June the 1st, the Veterinary* Assistant was despatched to visit certain villages with a view to discovering cases of the disease. On his return with information [illegible] the village of [illegible] uffaloes suffer- [illegible] said to have [illegible]

Professor Koch made the autopsy on the animal, and subsequently expressed it as his opinion that "the pathological changes found

OXEN.	Professor Koch's Methods of

DR. LINGARD'S REPORT.

in the intestines, were identical with those found by him in animals dead of rinderpest in South Af[illegible]

[illegible]

vessels. These vessels were subsequently placed in ice

Early on the following morning we again visited the same and other villages with a hope that we might obtain another autopsy; [illegible] the [illegible] to- [illegible] res-pectively, by a buffalo and a bull, suffering from rinderpest.

On our return the whole of our specimens were deposited in a tin box which was surrounded entirely on all sides with thick slabs of ice, and we proceeded to the Laboratory at Muktesar with the utmost despatch.

7. The conclusions * Professor Koch arrived at, at the termination of his experiments with regard to rinderpest in South Africa, were as follows:—

(*a*) The best method of transmitting rinderpest from one animal to another is by means of subcutaneous injection of virulent defibrinated blood, for by this means blood can be taken from animals during the earlier stages of the disease, when it does not contain any septic matter, but simply the contagium of rinderpest. Another great point in favour of using virulent rinderpest blood for the above purpose, is the important fact that a form of disease is produced with an incubation period of from three to five days.

(*b*) One five hundredth of 1 c.cm. of virulent rinderpest blood produced rinderpest in an animal after exactly the same time and manifested the same malignant symptoms as those animals which had received 10 c. cm., a dose 5,000 times larger. And later Professor Koch heard from South Africa that the inoculation of $\frac{1}{1000}$th of 1 c. cm. of blood had produced a like result.

(*c*) Glycerine, when mixed with virulent rinderpest blood, exercised a destructive effect upon the rinderpest virus.

(*d*) Distilled water, mixed with virulent rinderpest blood, delayed the symptoms of the disease, but later the symptoms appeared and the disease was just as violent and fatal as in the ordinary spontaneous cases of rinderpest.

(*e*) Virulent rinderpest blood is destroyed by prolonged exposure (four hours) to a temperature of 31°C. (87·8°F.); when injected into cattle, however, it produces "no protective action."

* Collated from Professor Koch's *interim* reports published in South African newspapers.

Immunising Cattle against Rinderpest. | OXEN.

DR. LINGARD'S REPORT.

Immunising effects of Bile.

8. Immunity from rinderpest is conferred upon cattle after the subcutaneous injection of 10 c. cm. of bile taken from the gall bladder of an animal which has succumbed to a virulent attack of rinderpest.

"This immunity sets in on the 10th day at latest, and is of such an extent that even four weeks afterwards 40 c. cm. of rinderpest blood could be injected without any injurious result. I therefore conclude that the immunity produced in such manner is of an '*active*' nature."

Experiments, however, have proved that an injection of less than 10 c. cm. rinderpest bile is insufficient to render cattle immune against rinderpest.

[illegible]

position, as is not uncommon, when an animal suffers from rinderpest. Under these circumstances, an abscess may form, which, however, does not seem to be detrimental to the process of immunisation."

"The protective properties of the bile will be of inestimable service in infected parts Nearly every case of rinderpest supplies a greater or lesser quantity of vaccine for those animals which are still healthy."

9. Regarding the immunisation from rinderpest, Professor Koch remarked, "I undertook many experiments for the purpose of ascertaining the best manner in which the bile is to be employed, and to investigate the nature of this remarkable process."

"First, a control experiment was made with the bile of a sound animal The result was, that such a bile had no immunising effect whatever. Also the bile of an animal suffering from rinderpest is as such by no means effective when taken from a rinderpest animal, that was killed on the 3rd day after the observed rise of temperature, and did not protect the injected animal against the disease. Even the bile from animals which survived the attack of rinderpest proper, but were suffering from secondary disease and died from such causes, was of a very doubtful or no protective value. The best results I always obtained were with bile as used at 'Susanna' farm and the qualities of which I characterized in my description of these experiments."

"For theoretical reasons I made an experiment by mixing larger and smaller quantities of virulent rinderpest blood with the rinderpest [illegible] make [illegible] both [illegible] c. cm. [illegible] treat[illegible]

DR. LINGARD'S REPORT.

with rinderpest atter, and I do 'erpest bile, *i.e.*, bile taken from the animals at the beginning of the disease, may be n the same e not stiga- n be r im- ctice, these experiments are so far of importance, as is herewith clearly proved, that contamination of the bile with blood must by no means be scrupulously avoided."

10. "Four animals were injected with 10 c. cm. of bile taken 'hese, the / on the eighth day after the first injection."

"No. I fell sick and died, as if no protective inoculation had taken place.

"No. II fell sick with slight symptoms of rinderpest, but soon recovered.

"No. III and No. IV exhibited no symptoms of any disease whatever. They proved themselves so strongly immunised that a subsequent injection of 20 c. cm. of fresh rinderpest blood produced no reaction of any kind. In accordance with these facts, the conclusion may be drawn that immunity began on the sixth day after the application of this bile."

11. "To ascertain whether smaller doses like 10 c. cm. were sufficient to create immunity, I injected three cattle with 1, 2 and 5 c. cm. of rinderpest bile each, and applied ten days later 0·2 c. cm. rinderpest blood. All these animals fell sick subsequently with severe symptoms of rinderpest, one inoculated with 5 c. cm. recovered, the other two died; it may, therefore, be concluded with safety that an injection with less than 10 c. cm. rinderpest bile is insufficient to render cattle immune against rinderpest."

Immunising power of injections of Blood serum from Rinderpest Animals.

12. "The protective properties of blood serum are not very great, for 100 c. cm. of such serum are required to protect an animal against an inoculation with a small dose of rinderpest blood. This immunity is in its nature merely a 'passive' one, and will only last during a short period."

"This method may be used in order to separate from infected areas those tracts of country which are still free from the scourge, by means of forming a broad belt between them in which all the cattle are inoculated with the vaccine."

DR. LINGARD'S REPORT.

"For protective inoculation on a large scale the above serum is not applicable, but by means of a mixture of *serum and virulent*

dose."

"From this fact, I judged that the immunity of these animals is of a much higher degree, and I believe it is an 'active' immunity, equal to that of a beast which has contracted rinderpest and recovered."

13. "To prepare the above serum from 'salted' animals, the blood is taken from the jugular vein and is conveyed into an air-tight bottle. It is then allowed to remain for 24 hours in a place kept as cool as possible and not disturbed. The fibrin and serum will then be found to have formed."

"The latter is to be taken off with a syphon and mixed immediately with fresh rinderpest blood in the proportion of 1 : 100 c. cm, *i e*, for each 99 parts of serum one part of fresh blood. This

blood. For this purpose I gave on the seventh day after the first injection, 1 c. cm and again seven days later 20 c. cm. of fresh blood. To preserve this serum for a certain time with all its immunising qualities, I did unfortunately not succeed, except by keeping it in the ice box."

1[illegible] "Should the necessity arise to employ the serum in a pre- [illegible] he vacuum [illegible] with other

Method of collecting Bile.

15. The autopsy should be held on the 6th* day or as soon after the animal succumbs to rinderpest (seventh or eighth day) as possible.

16. The animal is laid on its left side, an incision is made in the [illegible] er of [illegible] the [illegible] one [illegible] mi- [illegible] ais- [illegible] On

An Assistant, whose hands have been previously washed in sublimate solution (1 in 1,000), takes hold and raises with his left hand

* In South Africa Professor Koch slaughtered rinderpest animals for bile on sixth day of the disease.

DR. .INGARD'S REPORT.

the free border of the ribs, while with the right he grasps the gall
pres-
The
ıcision
with a sterilised scalpel at the most dependent part of the bladder, and so allow the bile to flow into a sterilised vessel, fitted with glass stopper or cotton-wool plug.

After collection, the bile should be placed in an ice chest or cool cellar, until required.

Operation necessary for the collection of blood from the jugular vein of an Animal.

17. The animal is thrown down in the usual manner, the feet being securely fastened together. A block of wood some 5 or 6 inches in thickness is placed under the neck in order to raise and extend the skin over the seat of operation. The exact spot for the incision is found by bending over the ear along the course of the jugular vein, the incision being made at the point where its tip reaches. After cleaning the surface of skin and washing it with a solution of sublimate (1 in 1,000), pressure is put on the jugular vein, low down in the neck, when the course of the vessel comes rapidly into view. An incision $1\frac{1}{2}''$ long is made through the skin transversely to the axis of the vein at the above-mentioned spot. An electro-plated canula is then pushed gently through the wall of the vein and the blood is caught in sterilised flasks. On withdrawal of the canula slight pressure is exercised for several minutes, with a pledget of cotton-wool saturated with sublimate solution, after which, as a rule, all hæmorrhage ceases. One or two sutures are then placed in the skin wound, and after thoroughly washing the surface of the skin, the animal is removed.

Injection of Bile or Blood.

18. The animal is thrown down in the usual manner, and the four feet securely fastened. A portion of skin selected to receive the injection, covering the anterior extremity of the sternum or of the dewlap, is grasped between the fore-finger and thumb of the left hand and slightly lifted up from the underlying tissues. The needle of the syringe containing the fluid to be injected is then inserted

passes into the subcutaneous tissues and not into the underlying
is free, before
When removing
left fore-finger
in at the point
the left mani-
o the dispersal

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19. Having now given the results obtained by Professor Koch and the technique of the different operations, it is necessary to enumerate the requirements in order that use may be made of the bile protective system :—

(*a*) Virulent rinderpest material.
(*b*) Inoculation of animal for bile.
(*c*) Injection of bile into animals.
(*d*) Animals undergo proof with virulent rinderpest blood.

(*a*) Virulent rinderpest blood is required for the inoculation of cattle in any district, unless the disease already exists in a virulent form.

(*b*) Inoculation of animals with rinderpest blood, in order that

to a virulent attack on the seventh or eighth day, but not later. The best bile when drawn from a rinderpest animal dead of the disease

ptic at time of
ve power for a
n injected into
14 days as at

(*c*) Inoculation of animals with approved bile—Ten cubic centimetres is the smallest amount which should be injected into each animal, and all bile should be carefully examined microscopically

it only as soon
later date, for,
injection with
ly after death,

for protective purposes, should be proved by inoculation of virulent rinderpest blood at a later date.

Previously it has been pointed out that the immunity conferred by the injected bile sets in on the tenth day at latest in South Africa, and therefore this day was chosen for the proof experiment.

RESULTS OF EXPERIMENTS UNDERTAKEN AT MUKTESAR, 7,500 FEET ELEVATION ABOVE SEA-LEVEL.

20 With the rinderpest material brought from Tanda it was the intention, if possible, (*a*) to reproduce the disease by inoculation of

DR. LINGARD'S REPORT.

blood, in order to obtain a supply at a later date for proving the immunising power of the bile; (*b*) to reproduce the disease with nasal discharge and dung; (*c*) to protect animals against rinderpest by the subcutaneous injection of bile, and other modified processes.

The following précis of the cases will show the course the disease followed in the animals inoculated.

Blood.

21. Immediately on our arrival at the Laboratory on June 4th, 7 P.M., two bullocks, Nos. I and II, were each inoculated in the dewlap with 10 c. cm. of the defibrinated blood.

No. I.—This animal's temperature attained 104° F. on the fourth day after inoculation and 105·8° F. on the evening of the sixth. Severe symptoms set in—purging, etc., and death took place on the morning of the tenth day from the time of inoculation.

On the fifth day of the disease with a temperature of 105° F. blood was let, and two animals, Bull No. XI and Cow No. XII, were inoculated with 10 c. cm each. The *post-mortem* disclosed the usual

jugular vein of No. I on the 11th June. The temperature rose somewhat suddenly to 105·8°F. on the 15th and attained the maximum 106·5°F on the 19th, the fourth day of the disease. This

No. XIX Bull was inoculated on the 21st June with blood drawn from the jugular vein of No. XI.

No. XII Cow.—First rise fourth day after inoculation; recurrent fever

norma

diarrl

blood still passed on the fourteenth day of the disease, July 11th; has now recovered.

No. XV Buffalo.—This experiment was made with a view to discover what course rinderpest takes in the Buffalo, and when inoculated from bovines, whether the virulence of the disease is increased or diminished. It was inoculated with 10 c. cm. of defibrinated blood taken from the heart of Bullock No. I at *post-mortem*, and inoculated five hours after death. A slight thickening occurred at the seat of inoculation, but it had entirely disappeared after 24 hours. The rise in temperature did not occur until the

eighth day after inoculation; maximum 105 8°F. attained on second day of disease, and normal temperature again recorded on the 4th day of the disease. A trace of blood and mucus was passed ' per anum ' at the time of the first rise in temperature, but only slight diarrhœa followed, and the animal was never entirely off its feed This animal was inoculated as control to cases Nos V and VI, first inoculation with bile.

Blood was taken from the jugular vein on the 25th June, and 10 c. cm. inoculated into No XXII.

No. XIX Bull—Inoculated with 10 c. cm. blood taken from the jugular vein of Bull No XI, *ante-mortem*. This animal presented a few symptoms of rinderpest, *viz*, shivering, high temperature on two occasions, blood-stained dung, etc., but the attack was only very slight and the animal was never off its feed. This animal was inoculated as a control experiment to Cows Nos. VII, VIII, IX and X on the 21st June 1897.

No. XXII Bull—Was inoculated on *June 25th, 1897, with* 10 c. cm. of blood taken from the jugular vein of Buffalo No. XV. The temperature began to rise on the fourth day after inoculation and attained a maximum of 107·9°F. on the fourth day of the disease, after which it declined, by the 7th day of disease, registered 99·7°F. Dullness and loss of appetite were the most marked symptoms, but the attack of rinderpest was very slight.

Bile.

22. On June 6th, 1897, at 4-30 P.M., two animals, Cow No. V and Bull No. VI, were each injected with 10 c. cm. of bile collected from an animal which succumbed to rinderpest, near Tanda, at 7 P.M. on June the 1st, and therefore 120 hours old. On the 14th June at 5 P.M. each animal received subcutaneously 10 c. cm. of defibrinated blood taken from the heart of Bullock No. I, in order to prove whether the injected bile had conferred protection against rinderpest.

No. V Cow—On the 19th, the sixth day after inoculation with [illegible]

normal limits after inoculation with blood on the 14th June, and no symptom was noticed until 5 P.M. on June 27th, and then only a little mucus and blood was passed with the dung, followed by a few drops of blood later, the animal was never off its feed.

At the time of the inoculation with blood on the 14th June, [illegible]

VIII, IX and X) were injected with 10 c. cm of bile, taken from a

rinderpest Bull, near Tanda, at *7 P.M. on June 1st, 1897,* and therefore utilised about 207 hours after collection or *post-mortem*. No rise of temperature was recorded in any of the four animals during the next ten days; so, on the morning of the 21st June, each animal was injected with blood in order to prove whether any protective influence had been conferred by the previous injected bile.

No. VII received 10 c. cm. of blood taken from the jugular vein of Bull No. XI; No. VIII, a like quantity, whilst Nos. IX and X only received 0·2 c. cm. of blood from the same animal, mixed with physiological salt solution.

The following are the principal symptoms noted in each of the four cases:—

No. VII.—Passed through a slight attack of rinderpest, but the only points noted were: a swelling the size of a cricket ball at seat of inoculation, hot but not tender, shivering on the 24th and 25th and later, dung watery with mucus and a trace of blood; the temperature during the next 14 days scarcely exceeding normal limits. On the 27th fluctuation was felt at the seat of inoculation, and on the 29th, a small white coagulum escaped from the wound, which quickly healed.

No. VIII.—Temperature was never raised above normal limits [illegible] swelling as large [illegible] ard and hot, but [illegible] or symptoms of rinderpest were observed.

No. IX.—This animal and No. X received only $\frac{1}{50}$th amount of rinderpest blood injected subcutaneously into Nos. VII and VIII; nevertheless, No. IX after 24 hours presented at the seat of inoculation a swelling 3 inches in diameter, hard, hot and tender, which increased on the following day to a ball 4 inches in diameter. For six days after inoculation the temperature did not rise, but on the seventh day, *viz.*, 27th June, it registered 104·4°F. and continued high until the evening of the 2nd July, when it attained a maximum of 108·5°F. It was only during the period the temperature was exalted that the animal appeared dull and left off feeding. On the morning of the 4th July, the thermometer registered 99·5°F., a difference of 9°F.

This animal was very ill, suffered from hyper-pyrexia, but the symptoms of rinderpest were not marked.

No. X.—Presented a hard, hot and tender swelling, 5 inches in diameter, at the seat of inoculation; the tenderness gradually disappeared a few days later. The temperature never exceeded normal limits during the next 14 days, and no symptoms of rinderpest presented themselves.

The control Bull No. XIX, inoculated with rinderpest blood, taken from the jugular vein of No. XI, passed through a very slight attack

Immunising Cattle against Rinderpest. | OXEN.

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of rinderpest, but did not succumb to the disease. Consequently, although the Cows VII and IX had slight attacks of the disease, animals VIII and X presented no symptoms of rinderpest.

24. The experimental researches commenced at this Laboratory by Professor Koch on June 4th, 1897, were undertaken with a desire to demonstrate his methods to the gentlemen assembled for that purpose, and at the same time to ascertain whether the means he discovered for immunising cattle against attacks of rinderpest in South Africa by the subcutaneous injection of bile and other body fluids, derived from such diseased animals, would prove as efficacious in protecting Indian cattle.

25 It will be as well first to consider what results we should have expected, if the Muktesar experiments coincided with those made in South Africa.

Animals inoculated with Rinderpest Blood.

The majority, 90 per cent. of animals inoculated with rinderpest blood, should have shown an abrupt rise in temperature on the third to the fifth day after inoculation, followed by the usual severe symptoms, *viz.*, purging, dysentery, etc., death taking place on the seventh, but not later than the eighth, day of the disease. A certain percentage, about 10, after passing through a serious attack of the malady, should have recovered.

Animals inoculated with Rinderpest Bile

All the cattle subjected to the injections of bile obtained from rinderpest animals should have presented, merely a hard, somewhat prominent and painful swelling, of the size of a man's fist, perhaps slight lameness for a few days, in some cases, but which would gradually disappear in the course of a couple of weeks, provided, however, that the bile was not in a state of decomposition, as is not uncommon when an animal suffers from rinderpest. During this period there should have been little or no constitutional disturbance.

Bile-injected animals afterwards proved with Rinderpest Blood.

After a period of ten days the bile-injected animals should be subjected to inoculation with a varying amount, generally 10 c.cm. each, of virulent rinderpest blood, in order to ascertain whether any protection had been conferred upon them individually. If this has been the case, during the above period no untoward symptoms would have been observed on examination of the animals, and their temperatures would have remained within normal limits, feeding, etc., as in health.

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Healthy animals inoculated with Rinderpest Blood as a control.

But completely otherwise would have been the condition of the healthy animals inoculated with a portion of the same blood as that used for proving the bile ones. The ordinary symptoms of rinderpest should have supervened and death followed in the majority of

Nos. I and II were inoculated by Professor Koch with defibrinated blood from Tanda. No. I—temperature rose on the fourth day, and later severe symptoms set in with loss of appetite, dulness, purging and dysentery; and this animal succumbed to a typical attack of virulent rinderpest on the seventh day of the disease.

No. II.—The temperature rose as in the case of No. I on the

cumbed to a secondary infection.

in both instances a normal temperature was recorded on the seventh day of the disease and the animals made an uninterrupted recovery.

On the 14th June blood was taken from No. I (*post-mortem*), and two animals were inoculated, *viz.*, Cow No. V and Bull No. VI. These had been previously injected with bile from Tanda. The effects of these inoculations were that the cow suffered from a comparatively *slight attack of rinderpest from which she recovered in a* few days, while the bull showed no symptoms whatsoever. The unprotected control animal inoculated with blood from the same source, which should have succumbed, or, at all events, had a very severe attack of the disease, only had a slight illness, no symptoms being manifest until the eighth day after inoculation and then only lasting 48 hours.

The other unprotected animals inoculated were No. XIX from blood taken from No. XI. In this case, if the disease was present, it must have been *of the slightest characte-*. No. XXII, *inoculated* with blood from No. XV, only passed through a mild attack of rinderpest, but although the temperature recorded was very high, the

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27. The following table shows in tabular form the different animals inoculated with *ante* and *post-mortem* blood derived from Bull No. I, which was injected with rinderpest material, 73 hours old, from Fyzabad District:—

Blood obtained from Tanda.

No. I.

Typical Rinderpest.

Very severe.

Ante-mortem blood drawn from Vena jugularis. | *Post-mortem* blood drawn from *Heart.*

Smart attack. XI. — Smart attack. XII. — Slight attack. V. — Slight attack. VI. — Slight attack. XV.

No typical symptoms. XIX. — Very mild. XXII.

28. From information kindly communicated by Professor Koch concerning the course of rinderpest in South Africa, it appears that the disease, both when acquired spontaneously and after inoculation, runs its course in a definite number of days, *viz.*, 7 to 8. In the event of an animal dying at a later date than the above, death is frequently not due to true rinderpest, but to a secondary infection, frequently caused by a distinct species of micro-organism (Streptococcus).

In South Africa the temperature of the inoculated animal, which generally remained up to the fourth or fifth day within normal limits, rose abruptly to 104°F. or over, remaining high up to the evening of the sixth day of the disease, when it rapidly declined until death supervened.

Of the seven animals inoculated at Muktesar with rinderpest blood, two only died, those being Bullocks, No. I and II, which were inoculated with blood directly brought from the case at a village near Tanda. The other five recovered after attacks of rinderpest varying in intensity.

29. To account for the severe type of disease found in South Africa, we must remember that the outbreak in that country was a new malady, affecting the animals of a country which had not been [illegible] iory of man, and [illegible] case of measles in [illegible] of the inhabitants [illegible] like instances with regard to other diseases, *e.g.*, small-pox, syphilis, etc., might also be added,

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inoculate [illegible]
which wa [illegible]
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29. To account for the severe type of disease found in South Africa, we must remember that the outbreak in that country was a new malady, affecting the animals of a country which had not been previously attacked by a like epidemic in the memory of man, and therefore spreading over 'Virgin Soil,' as in the case of measles in [illegible] nhabitants [illegible] nces with [illegible] also be

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The symptoms observed as a consequence at the Cape were of a far severer type and the mortality greater (90 per cent.) than that generally observed in the plains of India. In the Himálayas, however, the mortality amongst cattle suffering from rinderpest reaches 95 per cent., or even 98 per cent. in exceptional epidemics.

In the plains of India, the mortality from rinderpest may frequently be observed to be very slight, varying from 25 to 10 per cent. Probably several causes may be put forward to account for this

mortality.

30. *Breed.*—May perhaps in some instances bring about a certain

it is well known that

gainst anthrax, although

ulation with the same virus.

31. *Immunity.*—In India and the East rinderpest has been existant probably for hundreds of years, and it is extremely difficult to ascertain in such a vast extent of territory, what immunising effect may have been acquired by some of the cattle of this country. It is probable, however, that in some districts the cattle have received a certain amount of protection against rinderpest through their progenitors, but up to the present this has been impossible to estimate. At the same time, young cattle frequently succumb to a virulent form of the disease even when older cattle in the same district are little affected by

nown to suffer

own, however, t

n of rinderpest that it may even be overlooked by the initiated in this disease.

Influence of Heat on the virus of Rinderpest.

32. The most potent cause of the attenuation of rinderpest amongst the plain cattle of India,

of the higher temperat

hot season. Observers, l

pest, have pointed out that the virus of this disease may be destroyed

rinderpest animal were conducted in the open, and the ground besmeared with blood, nevertheless after a period of four hours (during three-fourths of the year) no infection would follow, if animals were kept off the infected area until the above time had elapsed.

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Attenuation of the Muktesar virus.

33. In the present state of our knowledge, it is impossible for us to give a satisfactory explanation of the causes which led to so rapid an attenuation of the rinderpest virus, as that which occurred when animals were inoculated with material brought up to the hills (7,500 feet elevation) from the plains. The animal, nine years of age, first to be inoculated, was bred and born in the plains, but of late years had been kept in the mountains. This animal died of a typical well-marked rinderpest in exactly the same time as was found in South Africa. But in the later inoculations the disease proved abortive, both in plain and hill cattle. We recognise, however, the fact that the period of the year (June), when these experiments were undertaken, was the very worst possible one, for obtaining virulent rinderpest in the plains.

[illegible] of rinder-
the virus
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v country,
June 1897
n addition,
vhether at-
greater at
ds its termination, when cases generally recover without any treatment.

Further, Koch has made a special point of the fact that in order to transmit rinderpest successfully, blood should be taken from the infected animal during the earlier stages of the malady, when it does not contain any septic organisms, but simply the contagium of the disease. The greatest difficulty, however, was experienced by us in finding any cases of rinderpest at all, in the Fyzabad District, so that the only virus obtainable for conducting investigations at Muktesar, had to be collected from the heart of an animal which had succumbed to rinderpest more than half-an-hour, before the autopsy was made. To one or more of the above causes, therefore, must be ascribed the cause of the attenuation of the rinderpest virus, which will have to be guarded against in future experiments.

Objections to the method.

34. (i) The [illegible]
keep at ordinary [illegible]
only green biles [illegible]
are only obtained rarely, the most frequent proportion being one in seven.

(ii) In this country where the cattle are small, 150 c. cm. (5·27 ozs.) of bile is all that one can hope to obtain from an animal, whereas in South Africa Professor Koch stated the amount averaged 500 c. cm., but that it was not at all unusual in large cattle for him

OXEN.	Professor Koch's Methods of

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to obtain 1,000 c. cm., equivalent to about 35 ounces. As in Africa

sufficient to inject 2·14 head of cattle.

(iii) It would be an easy matter to follow out this method of protection in districts where rinderpest already exists, but in case animals have to be protected in parts of the country where no disease is then present, virulent material would have to be transported to the scene of inoculation and animals inoculated, in order to provide bile in sufficient quantity. This is a serious objection to the method,

35. On the other hand, a very good instance of the great utility of the bile method is taken from Koch's experiments on a farm 'Susanna' on the Free State Border—

"Rinderpest broke out on the 20th January on the farm of Mrs. Lisching. In this case,
epizootic was due to the
belonging to infected fa
of cattle were much infe
had been kept separate were injected with bile which was taken from an animal that had died the day before of rinderpest, after a sickness of six days. This bile had a dark green colour, was almost clear, and had the same smell as bile from a sound freshly-killed animal."

"All the animals injected with bile showed more or less prominent swellings at the point o
some were lame for a few days.
second week and soon disappeare
had an abscess as a consequence of the inoculation. On the sixth day after the inoculation, four animals fell sick with symptoms of rinderpest. Of these, three succumbed, and one which had the disease in a less virulent form, recovered."

"Taking into account the time of incubation, it appears very probable that these animals were infected before the inoculation, even on the very day of the inoculation the animals might have been infected, because for the purpose of injection they were thrown on the floor of a Kraal in which those cattle suffering from rinderpest were kept every night. The floor of the Kraal was covered with rinderpest matter, and being moist, it was impossible to avoid soiling them where they were thrown."

"The total result for this group is—even if I consider the latter doubtful case of rinderpest—that out of 29 animals, in spite of the
by a
that
the

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15th February four animals indiscriminately out of this group and injected them with virulent rinderpest blood. The injection had not the slightest effect upon the animals, whereas two other cattle which were kept segregated in the experimental station fell sick and died with severe symptoms of rinderpest, after having received an injection of the same virus."

"The results I obtained in this way with the bile injection appear satisfactory. It proves, moreover, at the same time, that the bile injection has the same beneficial effect at rinderpest farms, where infection is a matter of natural consequence, as at experimental stations where the immunised animals may be re-tested by artificial *injection with rinderpest blood.*"

36. I have no doubt personally that Professor Koch's system of protection, by the use of Rinderpest Bile, as worked out by him in South Africa, really possesses the virtues he ascribes to it under certain conditions in that country, where the disease is of such a virulent character. But even the above experiments have not been *entirely without disaster, for, some cattle injected with bile have* ... herd ... ollow. ... fore- ... deter- ... grees of virulence found in rinderpest outbreaks.

37. There are, however, outbreaks of exceptional virulence in the Himálayas, and much less frequently such occur on the plains of India, more especially during the cold weather. With bile collected from such epidemics in the future, we may be able to obtain similar results to those which were demonstrated in the African outbreaks. But it must be clearly understood that cattle herded together at the commencement of an outbreak, cannot all be protected, even if injected with rinderpest bile, immediately the first case of disease is discovered amongst them, for, a varying percentage of animals must inevitably have contracted the disease previous to the use of the protective agent.

38. The experiments commenced at Muktesar, under the super- ... again procure blood from animals suffering from rinderpest in a virulent form, and subject them to inoculation with it.

39. On several occasions I have pointed out to Government the extreme importance of pursuing my investigations with regard to rinderpest, with material obtained from the most virulent source; otherwise much time would be lost and expense incurred. result being a protective agent only powerful enough to

O.

animals from a very mild form of the disease, but which would *render them susceptible to attacks of virulent rinderpest when* exposure occurred at a later date.

40. It is unnecessary for me to go into details with regard to the protective inoculation with serum, as this, in its present form, is somewhat unwieldy and difficult of carrying out, except in experimental form.

[illegible] which promises [illegible] plied with very [illegible] derpest blood to bile in the proportion of 1 part of the former to 9 of the latter. Researches will have to be carried out in order to test several of these side issues, for, probably we may find that *ordinary* bile, if mixed with virulent rinderpest blood, may serve the same purpose, and thus we should be able to do away with one of the great difficulties of the method, *viz.*, the requirement and attendant difficulty of obtaining [illegible]

[illegible] might arise.

42. If the bile method proves a success in this country when further trials with virulent material have been made, Government would be saved great expense and would probably run very little risk in the first instance by allowing their bullocks to undergo the protective inoculation. Again, it will be a great stand-bye, if during a campaign rinderpest should make its appearance on the line of communication (as was the case during the Chitral Campaign), the protective injection of bile could be had resort to, for the whole process would not incapacitate the animals for more than two weeks. The protected ones would be unlikely to again contract the disease, and they would be worth more than double their original value.

43. I would suggest, that in view of the recognised difference in the susceptibility to rinderpest exhibited by hill cattle and those of the plains, that two distinct sets of experiments be carried on concurrently, but separately, with a view to testing the efficacy of the rinderpest bile protective method and the period during which it renders the animals immune. The former could be undertaken at the Bacteriological Laboratory, Muktesar, while the latter would have to be arranged for on the plains, for it can easily be understood that by moving either set of animals from their accustomed habitat to a colder or warmer climate, as the case may be, the results of the experiments may and probably would be materially altered or entirely vitiated.

44. Whatever experiments are now initiated must be undertaken with the greatest difficulty and uncertainty owing to the want of proper accommodation for the experimental animals. Four of the *plains cattle have already succumbed to Enteritis owing to the altered* conditions of food, temperature, etc., to which they have been sub-

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jected during a recent period of rain lasting some days, when 20·43 inches fell.

45. A further report will of course be submitted when the experi-
something definite

ofessor Koch con-
rent questions of
interest connected with the study of this disease. The Professor indicated the lines which, in future work, would be most likely to lead to the advancement of our knowledge and produce results which may prove of the greatest benefit to Government with regard to the preparation of a serum of high protective power against rinderpest. The serum at present in use has been shown to produce a protective effect, when injected subcutaneously into healthy cattle, in quantities of not less than 100 c. cm. at one time. But future
possessing
be able to
he quantity
now used. For the preparation of such a blood serum Professor Koch points out that a centrifugal machine must be used—each cup capable of holding at least 500 c. cm. (½ litre)—with a velocity of 4 to 5,000 revolutions a minute. For this purpose an engine of several horse-power would be required, worked by means of steam, gas, oil, or electric power. Several of these centrifugal machines are now being used in, and within a few miles of Berlin for the manufacture of diphtheritic anti-toxin and other serums, and therefore it would be advisable, the Professor points out, to wait until an opportunity offers for thoroughly examining the machinery and becoming acquainted with its working, etc., before asking Government to obtain one for the Laboratory. However, later it will be necessary to get such a machine capable of being worked by mechanical means, for it would be impossible to obtain one capable of attaining the required velocity which could be maintained by manual labour continuously for four to five hours at a time, as would have to be done on each occasion when used.

47. Again Professor Koch remarked with regard to a probable modification of serum, "Should the necessity arise to employ serum in a preserved state, there will be no other way but to dry it in the 'vacuum apparatus,' a treatment which gave most satisfactory results with other kinds of serum." Consequently, it may also be necessary to provide the Laboratory with such a vacuum apparatus in the future.

A complete set of the charts (48 in number) recording the Temperature, etc., of the above cases was submitted with the manuscript report.

3. Veterinary-Captain Pease, Principal, Lahore Veterinary School, joined the party from the commencement, accompanying Professor Koch and Dr. Lingard to Oudh, where Rinderpest was discovered. He has entered very fully into the question, and his report is produced *in extenso*:—

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In accordance with your instructions, I placed myself in direct communication with Professor Lingard, and acting on his instructions, I proceeded to join the party, consisting of Professors Koch, Pfeiffer, and Lingard at Lucknow, arriving on the morning of the 29th May 1897.

2. Information having been received that there were cases of

appeared, ceased a day or two before our arrival; we then, in consultation with the district authorities of Fyzabad, proceeded to that station with a view of visiting Akhbarpur, where the disease had been

Veterinary Assistant. There were no cases of the disease to be found in any of the villages round Akhbarpur, but the Veterinary Assistant informed us of some disease in the villages near Tanda, a Tehsil some 12 miles distant. Thither we proceeded on the 1st of June, and having sent the Veterinary Assistant to ascertain, with certainty, where cases could be found, we proceeded to Rajipur, a village some 6 miles from Tanda, the same evening, and there saw three cases of Rinderpest. We made one *post-mortem* examination of a bull which had recently died, and found the typical lesions of Indian rinderpest present in the pylorus cæcum, colon, and small intestine. There was, however, no mouth eruption, nor inflammation of the mouth.

4. The symptoms in the living animals found suffering from the disease were, fever, discharge from the eyes, mouth, and nose, and diarrhœa. From the observations made here on these animals, Professor Koch concluded that Indian rinderpest is identical, in its nature, with that which he saw in South Africa. Flasks of blood from the heart and about 200 c. cm. of gall were collected from the dead animal. The blood was collected for the purpose of inoculating animals at the Imperial Bacteriological Laboratory at Muktesar, in order to produce the material necessary for carrying out the demonstration of the system of protection there. The next morning other villages, 6 or 7 miles from Tanda, were visited by Professor Koch, and nasal and mouth slime and dejecta were collected for experimental purposes. On the same day, we returned to Akhbarpur and took train for Kathgodam, *en route* to the Laboratory.

5. *Professor Koch's method of conferring immunity.*—Professor Koch's method of conferring immunity may be best given in his own words:—

6. *Method with pure bile from Rinderpest animals.*—One is able to render immune healthy cattle with the bile of such as have succumbed to rinderpest. In this case a single hypodermic injection of 10 c. cm. is sufficient. This immunity sets in on the

tenth day at latest, and is to such a degree that even four weeks afterwards 40 c. cm. of virulent rinderpest blood could be injected without any injurious effect. I therefore conclude that the immunity produced in such a manner is an "active" one, or confers more or less permanent immunity.

7 Of the injection the local result is merely a somewhat painful swelling of the size of a man's fist, which disappears in the course of a few weeks, provided, however, that the bile is not in a state of decomposition, as is not uncommonly the case when an animal suffers from rinderpest. In such circumstances, an abscess may form at the seat of the inoculation, which, however, does not seem to be detrimental to the process of immunisation.

8. ***Other modes of proceeding with bile.***—Regarding immunisation from rinderpest, Professor Koch has undertaken many

which survived the attack of rinderpest proper, but were suffering from secondary disease, and died from such causes, was found to be of very doubtful or of no protective value. It may be here remarked that typical rinderpest runs its course in 7 to 8 days at longest, and

theoretical reasons, experiments by mixing larger and smaller quantities of virulent rinderpest blood with the rinderpest bile were made

of virulent rinderpest blood were injected into an animal, which became immunised by this process. It appears, moreover, that the admixture of rinderpest blood with rinderpest bile even increases the immunising qualities of the bile, *i.e.* bile taken from animals at the beginning which, as we have seen above, is not of itself endowed with any immunising power, may be transformed in this way into an effective medium, and that even the bile of sound animals might

be used by such a process for the same purpose. Experiments in connection with this hypothesis are not ended as yet, and the matter is at present not definitely decided. Should these experiments give

natter to prepare, at any time,
and uniformly acting protec-
periments are so far of importance that they prove that contamination of the bile used for the protective inoculation with blood need, by no means, be scrupulously avoided. The results of the above experiments are anxiously awaited as the importance of this question is extreme from a practical point of view.

9. ***Immunity produced by serum.***—The blood serum of cattle which have recovered from rinderpest has a certain immunising effect upon healthy cattle when inoculated with it. Its protective properties, however, are not very great for 100 c cm. of such serum are required to protect an animal against an inoculation with a small dose of rinderpest blood This immunity is merely a "passive" one, and will only last for a short period. For protective inoculation on a large

withstand an injection of 20 c. cm. (about 300 drops) of rinderpest blood, a ten thousandth part of which is a fatal dose From this fact he judges that the immunity of these animals is of a much higher degree, and he believes that it is an active immunity equal to that of a beast which has contracted rinderpest and has then recovered.

10 It is particularly important to know that only 20 c. cm. of such serum are required to immunise an animal.

11. From the above experiments, Koch is led to believe that rinderpest can be eradicated with but little difficulty and within a comparatively short time by putting these methods into practice.

12. In infected parts of the country, nearly every case of rinderpest supplies a greater or lesser quantity of vaccine for those animals which are still healthy, and he is sure that thousands of cattle may be saved daily by its application

13. Methods demonstrated at the Laboratory. The method of protection by the inoculation of cattle with simple rinderpest bile is the one which Professor Koch demonstrated to us in India; unfortunately, owing to various circumstances, he was unable to spare the time to go through all his methods, as his time was too short, only one variation was made in the in
ture of virulent rinderpest blood to
explained others to me, and Dr.

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of bile
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must elapse before immunity is complete) to inject a very large quantity of virulent rinderpest blood (10, 20, or even 40 c. cm)

trol animals must take the disease and die or at least become very ill and exhibit diagnostic symptoms of the disease. This will prove that the bile-injected animals are immune from the disease. The control animals are, of course, used to show that the rinderpest blood with which the bile-injected animals have been inoculated, is virulent and capable of producing severe fatal rinderpest in unprotected animals. Failure in any of these points then will render the test negative or doubtful. If the bile-injected animals die, it will be negative, if the control animals do not take severe rinderpest it will be doubtful.

15. ***What is necessary for the demonstration.***—In order to carry out an experiment of the immunising properties of bile, then what is necessary is first to produce virulent rinderpest in some

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and unprotected animals to act as a control to the experiment; and fifthly, to observe that in the bile injected animals no rinderpest occurs, whilst in the non-protected controls rinderpest with its diagnostic symptoms occurs.

16. ***Method of infecting healthy animals with virulent disease.***—It is obvious that in carrying out these experiments, it is

produc-
provide
virulent
i been in

the *post-mortem* appearances of rinderpest. By this method every experiment has been positive in South Africa.

18. ***Best time for taking the blood for incubation.***—The blood for this purpose is best taken at an early stage of the disease,

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when the blood of the affected animal will generally be free from *putrefactive or other germs and contain only* the virus of rinderpest. It may well be taken on the third or fourth day after the first rise of temperature. The virulence becomes less at the end of the disease,

ing animals.—
mal, it is neces-
A round block
of wood is placed under the neck in a suitable position to raise it at
d

r
the seat where the incision is to be made and the part carefully cleansed with perchloride solution. The vein being now raised, an *incision two or three inches long* is made with a *sterilised knife* through the skin on to the jugular vein, freely exposing it. A sterilised trocar and canula is now pushed into the jugular, and the trocar being removed, the blood is allowed to flow into sterilised vessels. The wound is now carefully sutured, and the animal after

defibri-
shak-
ing for a considerable time in test tubes or flasks It is necessary to remember not to whirl the whisk round, but to beat the blood gently with it. The defibrinated blood is now ready for use. But previous to use, it should be strained. If the blood has been collected aseptically into sterile vessels and is kept in ice or very cool, it will remain unchanged for a long time, but if not, it will, of course, putrefy

21.
defibrin
injected subcutaneously into dewlap.

22. ***Quantity of blood used.***—The quantity of virulent rinderpest blood which has been found capable of producing virulent rinderpest in South Africa is $\frac{1}{1,000}$th of a c. cm., a very minute quantity. But in practice, in order to make certain of producing the disease, a very large dose, *viz.*, 10 c. cm. or about 150 drops, is injected.

23 ***Local effect of the inoculation***—The local effect of the subcutaneous inoculation of rinderpest blood, taken in this way, is only the production of a small swelling which rapidly disappears, causing little trouble as a rule. If the blood be contaminated with putrefactive germs, an abscess may of course form, or other serious consequences result.

24. ***Method of collecting bile for immunising cattle.***—The

round the posterior edge of the last rib. The flank is then cut

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back, care being taken to avoid wounding the intestines. The ribs are then lifted up by an assistant, pulling forwards, and the gall bladder is found lying A clean sterilised flask being ready, the gall its base by an assistant, in such a manner as to render it quite tense, and a small nick is now made into the most convenient part with a clean scalpel and the bile allowed to flow into the flask.

25. ***Amount of bile yield in Rinderpest.***—The amount of bile yield from animals dead of rinderpest necessarily varies considerably according to the size of the animal. Some small animals only yield about 100 c. cm., larger ones 200 c. cm., and Professor Koch informs me that the large South African oxen sometimes gave as much as a litre (1¾ pints). The quantity is invariably larger than in health, the fulness of the gall bladder being a prominent symptom *post-mortem* of the disease.

26. ***Period of the disease when gall is most suitable.***—This periods It has ken on the third day after the rise of temperature is endowed of itself with no immunising properties. It has also been proved that gall taken from animals which have exceeded the period of pure rinderpest is valueless or of doubtful value. The bile is best suited for immunisation and possesses its most powerful action on the seventh or eighth day of the disease.

27. ***Character of suitable bile.***—It has already been stated that the bile from all animals dead of rinderpest is not suitable for the purpose of conferring immunity against the disease, and it is important to be able to recognise bile which is fit for use. Bile collected on the seventh or eighth day which is of green colour, almost clear, free from offensive smell, giving off that of healthy bile only, and free from harmful bacteria is in a suitable condition. When it contains harmful bacteria, its physical and chemical properties are changed, and its smell differs from that of good bile, whilst its colour becomes yellowish or brownish.

28. ***Length of time which bile retains its properties.***—This important point has not, so far, been definitely settled, but it is known that in ordinary conditions it soon decomposes. If it be desired to keep it for any time, it must be carefully collected aseptically and kept cool in ice. How long, however, in these circumstances

animal to be operated upon having been properly cast and secured, the needle is introduced into the subcutaneous connective tissue under and to the side of the sternum, and the material injected and worked into the tissue a little by rubbing with the fingers. Care is necessary to see that the point of the needle lies free in the subcutaneous tissue,

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and is not sticking into the skin or the muscular tissue lying beneath. Koch usually injected some air with the bile.

30. ***Local effect of the injection.***—The effect of the local injection of the bile is the production of a considerable amount of swelling and inflammation, pain and tenderness. The swelling varies in size, but should not be less than that of a man's doubled fist. Koch lays some stress on the necessity for considerable swelling, and the seat of the injection has been purposely chosen to ensure this. The result of the injection, then, is sometimes lameness for

organisms, there is no general symptom produced by the injection

animal appa-

munity.—The manner in which the bile produces immunity is not certainly known, but its action is believed due to the irritation which it causes on inoculation. It has been above remarked that the bile in the earlier stages of the disease is incapable of conferring immunity, as is also the fact that, that from old cases has no action. It must be taken at the "acrue" of the disease, when the whole system is saturated with the poison The bile at this time is supposed to contain the greatest quantity of the most virulent virus of rinderpest, when we

prevents any absorption of the virus by the lymphatics from the seat of inoculation. The virus soon perishes at the seat of inoculation or undergoes certain changes there, and the products of its metabolism are mixed with the exuded material. This mixture is now gradually absorbed, and confers immunity in the same manner as do the anti-toxins of other diseases. This method of action is rendered the more possible for the reason that it has been experimentally proved that it is possible to mix large quantities of virulent rinderpest blood with the bile, and that the inoculation of cattle with this mixture confers immunity.

33. ***Quantity of Rinderpest bile required to produce immunity.***—To ascertain what doses of rinderpest bile are required to produce immunity, Koch injected three cattle with 1, 2, and 5 c. cm. of bile each, and gave ten days later 0·2 c. cm of rinderpest blood by subcutaneous inoculation, all these animals fell sick subsequently with severe symptoms of rinderpest, the one inoculated with

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immunising effect until ten days have elapsed since its injection. There is, as it were, a period of ten days' incubation of the immunity, during which, if the animal be exposed to the contagium of rinderpest, he may take the disease as easily as an animal which has not been protected It must, therefore, be remembered that rinderpest bile does not produce immunity until these full ten days have elapsed after which only is the proof against the disorder This is a most important point. It must not, therefore, be concluded in any set of experiments that, if there has been any possibility of mediate or immediate contagion during this incubative period, the method of immunisation is not an efficient one. What would be necessary to disprove the efficacy of the system would be, the infecting of animals after the proper period has elapsed since the immunising inoculation with suitable gall was made. Animals which have been exposed to the contagion before the protective inoculation is made, or which have been so soon afterwards, therefore may contract the disease *This exposure to contagion must naturally occur in the* case of outbreaks in India, where, owing to lateness in reporting outbreaks, to communal grazing, and to general carelessness a great number of animals in a village will always have been exposed to the disease by feeding and drinking, as well as by actual and mediate contact with diseased animals. In any attempt, therefore, to adopt the system in a village, we must necessarily inoculate a number of animals which have already the virus of the disease in their system, or which may take it in during the ten days which must elapse before immunity occurs. This is the more probable when we consider that an animal does not show any symptom of rinderpest at all until from three to five days have elapsed after taking in the poison, and the only symptom then shown is rise of temperature for 48 hours or so. Such animals would, of course, have an attack of the disease in the ordinary course.

35. ***Professor Koch's experiments at the Imperial Bacteriological Laboratory.***—We left Tanda on the 2nd June 1897, and proceeded as rapidly as possible to the Muktesar Laboratory, where we arrive[illegible] : virulent material, blood s[illegible] ed in ice on the journey, [illegible] Most of the blood broug[illegible], the only danger being that cold might have destroyed the virus. No bacteria were found in the blood on microscopical examination. In the evening of the 4th June, two bullocks, numbered I and II, received subcutaneously 10 c. cm. each of the defibrinated rinderpest blood collected at Tanda, previously strained. The inoculations were made with steril sed syringes into the subcutaneous tissue under

[illegible]

which is the first symptom of rinderpest, occurred on the 7th June, and the usual symptoms of virulent rinderpest, *viz.*, discharge from eyes, nose, and mouth, dulness, loss of appetite, staring coat, abdominal pain, diarrhœa, and dysentery followed in their usual

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course, the animal succumbing on the morning of the 14th, or on the seventh day of the disease. The temperature curve of this animal is a typical one of severe rinderpest and closely corresponds with those shown to me by Professor Koch and taken in South Africa. The *post-mortem* examination, conducted by Professor Koch himself, was one of typical Indian rinderpest, and confirmed his opinion that the disease here is identical in its nature with that which he met with in South Africa.

36. The temperature chart of No. II is also sent for perusal. This shows a typical rinderpest curve, the disease not so virulent in its nature. All the symptoms detailed in No. I were present, but the animal would probably have recovered had it been possible to feed him properly, as *post-mortem* examination showed that the lesions were healing. These two inoculations were made to produce bile in a proper condition for the inoculation of other animals with a view to conferring immunity. It will be seen, therefore, that No. I would be suitable, whilst No. II would not be. The bile taken from No. I was considered by Koch to be in a very good condition, and was utilised for the immunising inoculation of Nos. XIII, XIV, XVI, XVII, and XVIII.

EXPERIMENTS—GROUP II.

Production of Rinderpest.

37. Another experiment which was made was, with a view to [illegible] s [illegible] r [illegible] l about 10 c. cm. of the blood-stained dejecta as a drench mixed with water, and had the nostrils smeared with slime taken from a buffalo suffering from severe rinderpest. The temperature chart, sent herewith, marked 3, shows that on the 11th June, or five days after receiving the material, she was attacked by virulent rinderpest, all the symptoms of which followed, and that death occurred on the 18th or seven days after the rise of temperature.

38. No. IV, on the other hand, which received on the same day similar material taken from a bullock at Tanda had what appeared to be only a very slight attack lasting for five days, or from the 16th June to the 21st. The symptoms, however, were not well marked, and it is somewhat doubtful whether the animal really suffered from rinderpest or not, although it is believed that she did owing to the unfortunate fact that our rinderpest virus has almost completely lost its virulence; we have been unable to subject this animal to a test inoculation with virulent rinderpest blood.

EXPERIMENTS—GROUP III.

39. *Immunisation*.—Of the bile collected at Tanda, two animals, the only ones available for the purpose and numbered V and VI, received subcutaneously into the breast 10 c. cm. These animals were under my

Tanda bile, 5 days old.

charge. The injection was followed by the usual swelling at the seat

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Imperial German Government on special duty had to leave. He decided to apply the test to these animals himself before leaving This was done by taking the blood of No. I bull dead of virulent rinderpest and injecting 10 c cm subcutaneously; young buffalo No. XV. unprotected received a similar dose to act as a control to the test.

Results—The tested animals were placed in the rinderpest shed on the same day that they received the test injection of virulent blood The result of the test was that on the 19th, or five days after the inoculation, cow No. V became sick and passed through all the phases of a mild attack of rinderpest, lasting five days, after which she recovered and is now in good health. No. VI showed no symptoms of the disease at all, continuing in good health, until the expiration of 3 weeks, so that he appeared to be immune

41. The control animal No. XV, however, only had a very slight and short attack of the disease from which he was at no time very ill, although he had not been protected in any way, and although he received a large dose 10 c. cm. of the virulent material, he recovered.

42. *Doubtful benefit.*—It appears, therefore, from this experiment that cow No. V had no immunity conferred by the bile, or at least only a very slight amount, and at the same time that the rinderpest virus is losing its virulence.

EXPERIMENTS—GROUP III.

43. *Immunisation.*—In the meantime, more animals having become available, four animals Nos VII, VIII, IX, and X received 10 c. cm. of the original Tanda bile by subcutaneous inoculations in the usual manner. The bile had not apparently changed in its properties, and contained no more bacteria than before. These animals were inoculated with the bile on the 10th June, or when the bile was 10 days old. They remained in good health after the inoculation, and it was decided to test them with virulent material on the 21st of June.

Tanda bile, 10 days old

44. *Test of the experiment.*—Blood was taken for this purpose from the jugular vein of case No. XI which had been infected with rinderpest from bull I for this purpose. The blood was taken from the living subject in the usual manner on the seventh day of the disease which had been severe in him up to this time. A little variation was made in the manner of testing in this case inasmuch as VII and VIII received each 10 c. cm. of virulent blood, whilst IX and X received only 0·2 c. cm. of the blood mixed with physiological salt solution.

45. *Control of the experiment.*—At the same time, a small bull No. XIX unprotected, received an inoculation of 10 c. cm. of the same blood to act as a control to the experiment.

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in the case of the first animals V and VI, *viz.*, on the eighth day after bile inoculation, instead of the ten days laid down by Professor Koch.

53 ***Further experiments with Laboratory animals. Group V.—Rinderpest.***—So much then for the experiments regarding attempted immunisation with the bile brought from Tanda, experiments upon which, as has just been remarked, no reliance can

t be considered to give

Koch's method.

of virulent material for

oculated with 10 c. cm.

each of virulent rinderpest blood taken from the jugular vein of No I on the 11th June when the disease was at its height. Both these animals went through a severe attack of the disease, with all the typical symptoms, but both of them recovered and are now in good health. This further points to loss of virulence in the rinderpest blood.

EXPERIMENTS–GROUP VI.

[illegible]

fessor Lingard on the 15th June 1897.

56. ***Blood and Bile.***—The inoculation was varied in the case of No. XIII which received a dose of 9 c. cm. of rinderpest bile mixed with 1 c cm of virulent blood, as it is supposed that by this means the immunity conferred is more powerful and lasting. All these animals have been under observation since the inoculation, and have remained perfectly healthy.

57. It is a noteworthy fact that the injection of 1 c. cm. of rinderpest blood did not cause the disease in cow No. XIII, and this goes to prove that Professor Koch's observations on this point are correct, and leads us to hope for a simple method of procedure in the immunisation process.

58. ***These cases not tested.***—It is an unfortunate circumstance that our rinderpest blood has so greatly lost its virulence as to be useless for test purposes, which necessitates the use of the most virulent material, in order to prevent errors, we have, therefore, been so far unable to submit the animals mentioned in the above group of experiment to the necessary test.

59. ***Impossibility of giving a definite opinion on the*** [illegible]

remains to be seen.

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60. ***Differences in Indian and South African Rinderpest.***—Professor Koch has only dealt with the disease as it occurs in South Africa, which assumes a very virulent form, carrying off a very … hich it attacks (90-98 per cent.) and … with great severity. It has long … any interest in the subject, that certain contagious diseases, notably small-pox, measles, etc., when introduced into a country for the first time, the contagium having, as it were, a virgin soil to grow upon, assume a very exalted virulence, causing excessive mortality. The same is especially true of Rinderpest as may be remembered by those who were unfortunate enough to be connected with agricultural pursuits during the great outbreak in England.

61. In India, however, as in certain parts of Russia, where the disease is enzootic, the disease varies very considerably in its course and severity. We very often meet with rinderpest in what has been termed the "Benignant form." It may, indeed, be so slight as to pass unnoticed there being no symptoms but slight fever and looseness of the bowels. We have in fact similar conditions as are met with in the Steppe Cattle, which, as is well known to those who have given attention to the subject, perish from natural contagion at the rate of 30-50 per cent. and from inoculation with the natural unweakened virus in from 5-10 per cent. only.

62. ***Rinderpest here resembling Steppe Disease.***—The disease which we introduced to the Laboratory for the purpose of making experiments appears to me to closely correspond with Steppe disease.

63. The material was from an outbreak of not a very virulent nature, *the disease having been dragging on in the neighbourhood for* some very considerable time. It was taken from a dead animal in a village where the disease was evidently losing its virulence, as was

… he 11th June, when the disease was at its height, and all the typical symptoms of rinderpest present, and the temperature high (at the most suitable period in fact), and injected into Nos. XI and XII produced typical rinderpest as will be seen from the charts of these animals sent herewith, but the disease was evidently of a far less virulent nature, as both these animals recovered and regained their usual health, after a smart attack of the disease lasting from five to seven days respectively.

64. Blood taken from No. I *post-mortem*, and inoculated as a test to Nos. V and VI previously inoculated with bile from Tanda, produced in the cow an obvious though comparatively slight attack of rinderpest from which she recovered in a few

days. In VI the injection produced no effect at all, the animal remaining perfectly healthy. In the control animals, we find that although the animal is unprotected (see No. XV) the injection of blood from No. I produces, after seven days, very slight rinderpest, lasting practically only two days, as far as symptoms show, and from which the animal recovered.

65. Further, we find that the blood from No. XI, taken on the 21st June, on the seventh day of the disease, and inoculated into No. XIX to act as a control animal to Nos. VII, VIII, IX, and X did not produce the disease in this animal.

66. Again, blood taken from the buffalo No. XV and inoculated into XXII produced only a mild attack of the malady which showed none of the typical symptoms of rinderpest. Thus we have a decreasing scale of virulence in the material as follows:—

Tanda Blood

No. I — typical death. — No II — typical death.

XI	XII	XV	V	VI
Mild typical recovery.	Mild typical recovery.	Mild typical recovery.	Mild typical recovery.	*Nil*
XIX — Control slight recovery. *Nil* or		XXII — Mild, a typical recovery.		

None of these animals, excepting V and VI, had received any form of immunising injection.

67. Here, then, we have a state of affairs closely resembling what is described by E. Semmur as occurring in Steppe cattle, and the task of ascertaining what the significance of this may be must be left to future experiments *suggested explanations of the phenomenon.* It certainly appears to me that there are only two solutions of the phenomenon of the decrease in virulence of the rinderpest virus brought with us from Tanda, and these are, *first,* that some Indian cattle, especially those of certain plain districts, possess a similar immunity against rinderpest to that possessed by Steppe cattle, or *secondly,* that the virus of the disease has a tendency to lose its virulence in certain circumstances, the exact nature of which we are unable to decide. If the first solution should prove correct as seems probable, we can easily explain the decrease observed here. If the second, the explanation can only be unsatisfactory. It is known to some of us that the immunity which Steppe cattle possess is not shared by other breeds in Russia, and that, whereas the inoculation of natural unweakened rinderpest virus in them is followed by only 5-10 per cent. of casualties, the same inoculation in other breeds of cattle causes 90-98 per cent. of deaths.

68. It is also known to us that the virulence can be considerably lessened by passing the virus through Steppe cattle, whilst we are also aware of the fact that when such attenuated virus is passed

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[illegible]

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Tanda Blood

No. I typical death. — No. II typical death.

XI Mild typical recovery. — XII Mild typical recovery. — XV Mild typical recovery. — V Mild typical recovery. — VI *Nil*

XIX *Nil* or Control slight recovery. — XXII Mild, a typical recovery.

None of these animals, excepting V and VI, had received any form of immunising injection.

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. . . .

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68. It is also known to us that the virulence can be considerably lessened by passing the virus through Steppe cattle, whilst we are also aware of the fact that when such attenuated virus is passed

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through other races more susceptible, the virulence increases generation by generation.

69. ***Indian Rinderpest.***—My own observations and those of Thacker and others are to the effect that we meet with many outbreaks where the mortality is not greater than 30-50 per cent. But, on the other hand, we often hear of severe outbreaks in which it is 80-90 per cent. This can only be explained either by the comparative immunity of certain cattle to the disease, as is the case with Steppe cattle, or to some decrease in the virulence of the virus owing to some influence exerted on it from outside, such as partial dessication or [illegible]

[illegible]

ow [illegible]

thousands of cases, been led to the conclusion that the heat and dryness were the causes of the lack of virulence in the disease as met with in the plains as opposed to the great virulence and severity of the disease observed in the parts of the Himálayas. The observations I made showed, plains 30-50 per cent. deaths, parts of the Himálayas 90-98 per cent. deaths. We are well aware from experiments already made that a vaccine can be prepared by exposure of the virulent material to a temperature of 117·0 F. to 120·0 F. for 20 minutes. This exposure so reduces the virulence that the material can be inoculated and produce immunity without causing severe disease. These temperatures are not unfrequently met with in India in the sun, and the influence of this on the virus would, it appeared to me, sufficiently explain the low mortality in some outbreaks.

71. In some parts of the Himálayas on the contrary, where the temperature is cool, and the air moist, the disease is very severe.

72. ***Indian bile less protective than the South African.***—These various points can only be settled by close observation and experiments. But there is one very important point which may arise in connection with this slight virulence. It is very possible that the bile from an animal dead of such a virulent form of the disease as has been occurring in South Africa especially in view of the experiments made by Professor Koch in regard to mixing virulent blood with the bile to increase its immunising power, may be endowed with far higher powers of conferring immunity. From theoretical reasons this seems to me not improbable. The bile appears to owe its protective power to the rinderpest virus it contains, and Koch's experiments of adding blood increase such power. It stands to reason therefore that if this be the case, the milder the virus, the less will be [illegible]

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74. Professor Koch's experiments in
the immunisation process at the "Susanna
do a considerable amount of good E
Rinderpest broke out there on the 20th
farm on the 2nd February, and found the stock of 180 head already much infected. Twenty-seven animals were dead, and at least 50 showed more or less clear symptoms of rinderpest. Experiments in protective inoculation with the animals which still appeared sound were undertaken, and 18 diseased animals were injected with blood a proportion of phenol and lesser proportion of bile. Ten animals which appeared sound received the same phenol blood, and 29 cattle which also appeared sound and had been kept separate were injected with bile which was taken from an animal which has died after an illness of six days. On the sixth day after the inoculation, four animals fell sick with symptom of rinderpest, of these three succumbed, and one which had the disease in a less virulent form, recovered. There was every possibility of these animals having been infected before the inoculation, for which they were thrown on the floor of a "Kraal" in which cattle suffering from rinderpest were kept every night, and this floor was covered with rinderpest matter. Out of 29 animals, in spite of the extraordinarily unfavourable circumstances, 25 were preserved by a single injection. To prove beyond a doubt that the animals so treated were absolutely immune, Koch inoculated four of them with virulent blood, and, at the same time, two unprotected ones to act as control. The four remained well, whilst the controls died with severe symptoms of rinderpest. From the above, it will be seen that the system may be adopted with advantage even in unpromising circumstances.

75. *Inoculation of Transport animals on service.*—It seems highly probable that the method might be very useful in the event of outbreaks of rinderpest on the lines of communication. It would have the result at any rate of stopping an outbreak in a fortnight, and the inoculated animals would be proof against the disease afterwards.

76. *Inoculation of Transport animals before service.*—It would be very useful to inoculate animals intended for service in parts of the country where rinderpest is prevalent. The advantage of having protected animals on these expeditions would be enormous, as they would be able to march unscathed through a country however severely infected it might be.

77. *Inoculation of all Government cattle.*—This might in the course of time be gradually carried out; I would especially draw attention to the advantages following the protection of Government breeding bulls previous to sending them out to their districts

78 *Inoculation during outbreaks amongst Transport cattle.*—In the case of outbreaks among transport cattle in Cantonments, the system, should it prove successful might with great advantage be adopted. There would be material at hand from the animals already attacked, and many animals might in these circumstances be saved and protected against the disease in the future.

OXEN.	Professor Koch's Methods of

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79. ***Inoculation during outbreaks in the districts.***—But in the case of outbreaks in the districts, it could not well, it seems to me, be utilised to any extent at present. It must, in the first place, be remembered that the immunising process takes a considerable time, nearly or rather quite ten days, and that before this time has elapsed, should the animal be exposed to the contagion, it will take the disease.

80. In outbreaks of rinderpest, therefore, in this country, where

vails in the management of matters of this kind; what is likely to occur in nearly all outbreaks may be well illustrated by the following case which is reported in the *Diamond Fields Advertiser*. The disease appeared in a herd of 248 cattle, of which only one or two were observed to be sick. These were instantly removed from the herd and isolated, while the rest were inoculated. This was done on the 27th February. On the 12th March, no less than 40 had taken the disease, but the remainder were apparently doing well. Now we are pretty certain, judging from all the experiments which have been made with rinderpest bile, even when it is mixed with a considerable quantity of virulent rinderpest blood, that its inoculation into healthy cattle does not cause rinderpest. The small experience which we have so far had in this country proves this. How then are we to account for the 40 head being attacked? Simply because during the incubation period of the immunity or before the inoculation period they had been exposed to the disease and become infected

already been stated in the South African enquiry that the best results are to be obtained in operating on healthy cattle. If any method of inoculation against rinderpest is to become spread over the country, it can only safely be done by feeling our ground carefully and introducing it very
lating at various centres animals
immune and also by operating t
animals. It might be very useful to inoculate a portion of the cattle distributed as "Thakavi grant" in villages where rinderpest has been very severe, and there is danger of recrudescence owing to which the animals bought with the "Thakavi loans" perish, and the unfortunate *raiyat* finds himself worse off than before.

82. ***Drawbacks of the present system.***—The present system has serious drawbacks owing to which its application to the

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for long. These are all serious questions which must be left to the proper authorities to settle.

83. ***Koch's other methods more hopeful for practical application in India.***—The further experiments in regard to the use of bile from healthy animals and its admixture with virulent blood, or the possibility of using other material with which the virulent blood may be mixed and at the same time produce immunity, seem to render it very probable that the means of manufacturing a more or less artificial protective medium seem to me to promise the best results in the matter of providing large quantities of vaccine, and it is to the solution of these problems that I look forward with most hope.

84. ***Possibility of teaching Veterinary Assistants the system.***—The system if it be on the lines of any laid out by Professor Koch can be easily taught to some of the more intelligent of

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and
ught,
if the Government decided to extend the course to three years

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of
my experiments with dried rinderpest matter, several animals were fed with the dung, flesh, and skin of the pest animals, which substances were dried for a fortnight in the shade and soaked before feeding. The animals remained perfectly sound." In accordance with these facts, the conclusion may be justified that the pest virus in its different qualities, is soon killed by dryness, and that the dry process forms one of the simplest and best ways to render rinderpest matter innocuous.

86. This has a most important bearing on the hide trade. I pointed out so long ago as 1894, that drying destroyed the rinderpest virus and that dried hides do not form a danger in the transmission of rinderpest.

87. This fact will also again bring into prominence my recommendation for the establishment of skinning enclosures outside every village, in which the *Chamárs* should be made to skin dead cattle, as a part of the village arrangements. This will limit the spread of rinderpest in a very marked manner. If the animals be skinned, as suggested in my Annual Report of last year, the sun will soon destroy the rinderpest virus. The skins should be dried in the enclosure and on no account washed in the village tank. The adoption of simple methods of this kind will go a long way to help the people and are really of very little trouble.

88. In conclusion, I have to thank Professor Lingard for his courtesy and assistance during my deputation, and for giving me

uring my vacation.

Rajputana Veteri-

VETERINARY-CAPTAIN HAGGER'S REPORT.

VETERINARY-CAPTAIN HAGGER'S REPORT.

With reference to your endorsement No 3841-G—869, dated 28th August 1897, I have the honour to submit the following remarks on Dr. Koch's method of inoculating cattle as a preventive against rinderpest, as witnessed by me at Muktesar in June last.

2. Dr. Koch clai... bile, taken from the g... pest on the sixth day... animal, render that animal immune to the disease after the sixth day.

3. He distinctly points out that it is not a curative agent, and ... n either just before, or within ... to suffer from the disease, but ... hey have been inoculated, and before immunity has been given, *i.e.*, before the sixth day, suffer less in proportion to the number of days that have elapsed after the immunising agent, *viz.*, bile, has been injected, and that after the sixth *day, they* enjoy complete immunity.

4. The correctness of the above conclusions was amply proved by experiment at Muktesar, where six bullocks were inoculated by Dr. Koch in the manner described, and, after the lapse of six days, resisted the disease after being inj... from animals that were either suffer... pest, and I understood Dr. Koch to... animal treated according to his me... provided that the process was carried out under proper antiseptic precautions.

5. Dr. Koch, reasoning on his experience as Bacteriologist, holds a theory which, however, he has not yet worked out by experiment, *viz.*, that the serum of an animal that has been rendered immune and resisted virulent blood, will protect others against rinderpest. The anti-toxin thus obtained should consist of one part of virulent blood to 99 of serum, of which mixture 20 cubic centimetres are *injected*.

6. With regard to the second paragraph of Inspector General's letter No. 1117–191 M., received under your endorsement above quoted, I have the honour to state that the Ajmere Veterinary School being bounded on three sides by forest preserve in which cattle are not permitted to graze, is, in my opinion, singularly well situated for carrying out experiments in connection with rinderpest, with a minimum risk of conveying contagion to cattle in the surrounding district, and, should the Inspector General, Civil Veterinary Department, desire it, and the Agent to the Governor General approve, I am prepared to take up the work as soon as the necessary material can be procured.

5. Veterinary-Captain Raymond, Superintendent, Civil Veterinary Department, Bengal, was first deputed by the Government of Bengal to Bombay, to consult Professor Koch, and after his interview expressed the following opinion:—

Immunising Cattle against Rinderpest. | OXEN.

VETERINARY-CAPTAIN RAYMOND'S REPORT.

VETERINARY-CAPTAIN RAYMOND'S REPORT.

" ... to be perfectly ... nfront the untrai... are already happening in South Africa.

" The preventive treatment only confers immunity about six to eight days after inoculation. during the interval the animal may catch rinderpest

" It happens that Cattle Plague is latent in the system for about three days before any symptom is noticed. The inoculation with preventive serum in such a case would not prevent the animal suffering or dying of the malady.

" Moreover, it is at least possible that clumsy management by the inoculator may infect a healthy animal with Cattle Plague at the very moment he is injecting the protective serum.

" There can be no doubt that in the Laboratory and in South Africa in skilled hands, Koch's methods are quite successful.

" *It remains to be seen if, out here, any modifications are necessary.*

" In any case it is desirable to remember that the matter has scarcely got beyond the Laboratory stage, in spite of Press notices and reports."

6. When it was decided that Professor Koch should visit Muktesar, Veterinary-Captain Raymond was again deputed to attend the demonstration: the results following his deputation, and the experiments carried out by him up to date, are contained in the following report, which it is deemed advisable to print *in extenso*:—

In answer to your No. 1537-A of 14th September, which reached this office during my absence on tour, I have the honour to report on the subject of rinderpest as follows:—

1. In paragraph 150, page 14 of my Annual Report for 1896-97, I drew attention to Dr. Koch's experiments in preventive inoculation which he was carrying out in South Africa, and I added, " If it is found to be safe in India, as at the Cape, I purpose to employ this method of experiment "

2. It will be within your recollection that as soon as it was known that Professor Koch had landed in Bombay, the Government of Bengal always solicitous to reduce the great annual losses from rinderpest, deputed me by telegram to confer with him.

3 Upon my reporting that Professor Koch was willing to demonstrate his system, the Bengal Government at once expressed its willingness to defray the expenses

4. In the meantime, the Government of India had taken the matter into consideration, and Bengal withdrew in favour of the

VETERINARY-CAPTAIN RAYMOND'S REPORT.

5. While at Muktesar, I saw Professor Koch inoculate several animals with bile and watched the effect, which was confined to the formation of a swelling near the seat of inoculation. No symptoms of disease were shown by the animals.

6. I did not witness any demonstration of the serum treatment.

7. The following is an extract from my letter No. 771 V.D., dated 26th

"Profes has still to be s

Professor Koch impressed on me that much remains to be done in this direction. If Government is willing, I can easily seek to apply the knowledge acquired.

8. With regard to paragraph 2 of No. 1118—191 M. from the Inspector General, Civil Veterinary Department, which you forward, I have th out part Kanti. for scar immuni

9. B creased amongst cattle owners, and there is some risk of infection being carried I am, therefore, glad to state that Government has under consideration a scheme which will render it possible for experiments to be carried out without any danger to other cattle

10. I beg to bring to notice some work which I have carried out in connection with rinderpest inoculation.

11. In the month of May, an outbreak of rinderpest was reported from Munshigunge, and I directed my Veterinary Assistant to send me some material from a sick case for experiments. Unfortunately it arrived in such a decomposed condition that the result of an experiment on sick calves was a failure.

12. On the 25th June, a bullock belonging to the Chitpore Municipality was admitted at Belgatchia, suffering from cattle plague and died. The *post-mortem* report is appended (Appendix I).

13. From this animal, two calves were inoculated, but proved to be immune, and as the outbreak was sporadic, my material came to an end.

14. But from the bile collected from the bullock, I inoculated four calves, four bulls, and three bullocks. The dose was 10 c. cm. each.

The result went to prove that the operation was perfectly harmless. The animals had a slight swelling at the seat of inoculation, but they showed no sign of any kind of disease and fed and worked as usual.

15. On the 31st August, I received an urgent telegram from Muzaffarpur. Upon my arrival, I found Mr. G. R. Toomey of the told me August, ome 400

VETERINARY-CAPTAIN RAYMOND'S REPORT.

or 500 head of cattle had died in the neighbouring villages. Mr. Toomey had heard that I was desirous of experimenting with rinderpest, and in the most public-spirited manner expressed his willingness to assist me, undeterred by some hostile criticisms of the method which it was my duty to send to him.

16. It should therefore be noted that Mr. G. R. Toomey is the pioneer in India in what may possibly become a very important public benefit. Besides the risk of the loss incurred by Mr. Toomey (for a new thing is always more or less risky), he has refused to recoup himself from the small sum given by Government for experiments, stating that he would rather see the money used for further work

17. Having decided upon inoculation, the next thing was to procure suitable materials It was obviously out of the question to kill any of the cattle owing to the religious opinions of the people. On the other hand, observations upon cases that had succumbed during various outbreaks had shown me pretty clearly that the bile was very often unsuitable in cases that had died in the usual way. Unless the bile can be removed at once, it is nearly always useless Hence there was an element of uncertainty over the work which it was desirable to remove. There is fortunately no prejudice against killing buffaloes. I therefore recommended Mr. Toomey to procure some buffaloes. I there obtained a typical case of cattle plague wherewith to infect the buffaloes. This case (Buffalo A) showed all the symptoms in a marked degree and soon died (for *post-mortem* appearances—see Appendix II).

[illegible] eiving material [illegible] young calf that [illegible] cattle plague. Four other buffaloes (Nos. 2, 3, 4, and 5) were also treated with material from Bullock A.

19. Having prepared the way for further work, I returned to Calcutta to my other duties, leaving my Assistant to report by wire when the temperatures of the buffaloes were rising. I returned to Kanti, and on the 3rd September, Buffalo No. 1 was shot (*vide* Appendix III). The bile was extracted and placed in ice. On completion of the *post-mortem* examination, I examined the bile under the microscope, moreover the colour and odour were satisfactory. In the afternoon I injected 10 c. cm. of the bile into each of 12 head of cattle, which were then branded $\frac{K}{T}$ 1-12.

20. On the 5th September, Buffaloes Nos. 2 and 3 were shot (*vide* Appendices IV and V for details). Bile was extracted from both animals, found to be good, and placed in ice. The bile from Buffalo No. 2 was used the same afternoon to inject 28 head of cattle which were branded $\frac{K}{L}$ 1-28.

21. On the 6th September, I injected 32 head of cattle with bile from Buffalo No. 3, which had been kept in ice. This batch was branded $\frac{K}{—}$ 1-XXXII.

OXEN.	Professor Koch's Methods of

VETERINARY-CAPTAIN RAYMOND'S REPORT.

[illegible] 4 was [illegible] tracted [illegible] noon, I [illegible] details [illegible] imal, I [illegible] herd I [illegible] others were cows in calf. This batch was branded [illegible]

From the same animal I secured a quantity of virulent blood for testing experiments. This was placed in ice. Some of the blood and the remainder of the bile was also placed in ice and taken to Belgatchia.

24. I wish here to mention that Mr. Toomey told me that cattle [illegible] neighbourhood [illegible] ds his [illegible] als on [illegible] ue by suffering from a previous attack.

[illegible] 108 [illegible] y in- [illegible] and [illegible] two [illegible] ally none of the animals appeared to suffer in the slightest degree.

26. Professor Koch states that the bile injection confers immunity not later than the tenth day.

27. In order to test the immunity of the animals after the bile treatment, 6 bullocks were selected simply because they were blind or lame—

(*a*) bullocks $\frac{K}{T}$ 2 and 10 each received subcutaneously 20 c. cm. of virulent blood from Buffalo No. 5 on the 10th September, that is to say, seven days after the bile inoculation (see Appendices VIII and IX);

(*b*) bullock $\frac{K}{L}$ 15 received subcutaneously 10 c. cm. of virulent blood from Buffalo No. 5 on the 12th September, that is to say, after seven days after bile inoculation (see Appendix X);

(*c*) bullock $\frac{K}{L}$ 16 received 20 c. cm. at the same time, under the same circumstances (see Appendix XI);

(*d*) bullock $\frac{K}{L}$ 1 (Appendix XIII) received 10 c. cm. of virulent blood from a case of Belgatchia (*vide* Appendix XII) on the 16th September, that is, eleven days after inoculation with bile.

(*e*) $\frac{K}{L}$ 2 received 20 c. cm. of the same blood on the same date and under the same conditions (*vide* Appendix XIV).

All these animals proved to be immune.

Immunising Cattle against Rinderpest.	OXEN.

VETERINARY-CAPTAIN RAYMOND'S REPORT.

28. The dose of virulent blood used in these test cases is said by Koch to be respectively 5,000 and 10,000 times greater than a fatal dose.

29. The experiments above recorded go to show that Professor Koch's preventive treatment with bile promises to be successful in Bengal. The exact amount of success can only be determined by future experiment.

30. Here again Mr. G. R. Toomey has rendered great assistance by permitting the inoculated bullocks to be branded, so that each animal might be identified later.

31. I have performed another experiment to ascertain if by any chance bile in this province would confer immunity quicker than in other climates. For this purpose I injected calves with 10 c. cm. of bile and five days later tested them with virulent blood from Buffalo No. 5. They have all re-acted in temperature, three developed genuine rinderpest, and one died.

32. Experiments are proceeding.

APPENDIX I.

Post-mortem appearance.

Gall Bladder—was full containing a greenish fluid of a peculiar mild colour.

Lungs—were congested and emphysematous, which are the most characteristic points in the disease rinderpest.

Trachea Larynx and Bronchial tubes—were merely congested with an ulceration close to the vocal chords in the Larynx.

Buccal and Schniederian membranes—were almost all right, but

—There was conges-
t found. The fourth
ncy of throwing off

and infiltrated,

APPENDIX II

Post-mortem appearances of Bullock A, died of Rinderpest at Kanti on the 29th August 1897.

Mouth—normal.

Pharynx—congested, bran-like deposit on the side of the Epiglottis.

Larynx and Trachea.—The former was congested with ecchy-

congested.
asum normal: Aboma-
erosions and croupous

chymosis, croupous
nucous membrane
thickened in places. Large intestines congested in patches and casts. Rectum congested in patches and stripes

Spleen and Liver—normal, and Gall Bladder contained clear bile.

Kidneys—slightly congested.

Bladder—congested, with a few spots of ecchymosis.

APPENDIX III.

DISEASE.

Rinderpest.

Notes of Case.

Name { *Buffalo Calf.*

Case Book No. 1.

Infected from Bullock No. "A" also from a Cow-calf which died showing the typical signs of Rinderpest, on the 27th. August 1897.

Provided bile with which $\frac{K}{\Gamma}$ 1-12; 12 heads of cattle were injected.

Dose.—10-c. c. m.

Date of Inoculation.

27th. Aug. '97 at 1-30 P.M.

Result.—Shot 3rd. Sept. 1897.

1897. August	27		28		29		30		31		Sept 1		2		3		
Time	M	E	M	E	M	E	M	E	M	E	M	E	M	E	M	E	M
Bowels																	
Urine																	

Temperature (Fahrenheit): 107°, 106°, 105°, 104°, 103°, 102°, 101°, 100°, 99°, Normal Temperature of body 98°, 97°

Day of Dis. / Pulse / Resp / Date

Post mortem appearances of Buffalo No. 1 fed on dung and blood from Rinderpest and destroyed on 3rd September 1897.

Mouth.—Erosions on Gums.

Larynx and Trachea.—Very slightly congested, *otherwise normal.*

Lungs.—Slightly Emphysematous.

Heart.—Normal.

Stomachs.—First three stomachs normal, and the last one congested, and mucous membrane thickened.

Intestines.—Small intestines congested with mucous membrane thickened and corrugated. Large intestines congested, and Rectum congested with streaks, and mucous membrane thickened and corrugated.

Spleen
Liver
Bladder
Kidneys } Normal.

APPENDIX IV.

DISEASE.

Rinderpest.

Notes of Case.

Name { *Buffalo.*

Case Book No. 2.

Infected from Bullock No. "A" suffering from Rinderpest on the 29th. August, 1897.

Provided bile with which K 1 to 28.

28 Heads of cattle were infected.

Dose.—10-c. cm.

Date of Inoculation.

29th. Aug. '97 at 1-30 P.M.

Result.—Shot, 5th. Sept. 1897.

1897. August	29		30		31		Sept. 1		2		3		4				
Time.	M	E	M	E	M	E	M	E	M	E	M	E	M	E	M	M	E
Bowels																	
Urine.																	

Temperature (Fahrenheit): 107°, 106°, 105°, 104°, 103°, 102°, 101°, 100°, 99°, *Normal Temperat. of body* 98°, 97°

Day of Dis. / *Pulse* / *Resp.* / *Date*

Post Mortem Appearances of Buffalo No. 2.

Mouth.—*Erosions.*

Tongue.—Erosions and bran-like deposits on both sides.

Larynx.—Congested with ecchymatic spots on *Epiglottis.*

Trachea.—Congested with large ecchymatic spots.

Lungs.—Slightly emphysematous and congested in patches.

Heart.—*Endocardium congested* and pericardium slightly congested at apex.

Stomachs.—First three stomachs normal and abomasum congested with petechial patches.

Intestines.—Small intestines congested, in some parts with mucous membrane thickened, Peyer's patches congested, croupous membrane in some parts and in others yellowish tinge. Large intestines erosions in caecum with fibrinous casts.

Kidneys and Liver.—both *slightly congested.*

Bladder.—Slightly congested with ecchymosis.

Spleen.—Normal.

APPENDIX V.

DISEASE.

Rinderpest—

Notes of Case.

Name { *Buffalo.*

Case Book No. 3.

Infected from Bullock "A" suffering from Rinderpest on the 29th. August 1897.

Bile taken for injection.

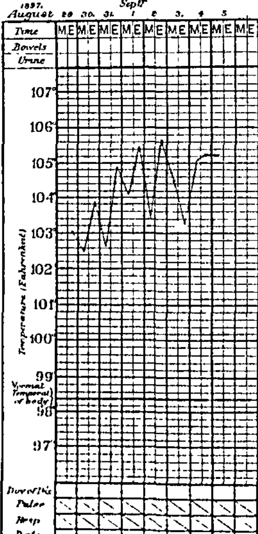
Not used on same day.

Injected 32 heads of cattle on the 6th. September 1897 at Dumuria.

Date of Inoculation.

29th. Aug.'97 at 1-30 P. M.

Result.—Destroyed at 8 A. M., on the 5th. Sep. 1897.



Post mortem appearances of Buffalo No. 3, fed on dung and blood from a case of Rinderpest, and destroyed on the 5th September 1897.

Mouth, Tongue, Pharynx, Larynx, and Trachea.—Normal.

Lungs and Heart.—Lungs emphysematous and slightly congested and the latter normal.

Stomachs.—All stomachs normal except abomasum, which was congested and the mucous membrane thickened.

Intestines.—Small intestines congested with occasional patches of ecchymosis near the Ilio-Caecal valve and the mucous membrane thickened and corrugated

Bladder.—The fundus of Bladder slightly congested.

Spleen, Kidneys, and Liver.—were all normal, but the mucous membrane of Gall Bladder was slightly congested

DISEASE.

Rinderpest.

Notes of Case.

Name { *Buffalo.*

Case Book No. 4.

Infected from Bullock "A" with Rinderpest on the 29th. August 1897.

Bile taken and injected into 21 heads of cattle at Dumuria at 4 P.M. of the 7th. September 1897.

Series—K 1-xxi.

Date of Inoculation.

29th. Aug. '97 at 1-30 P.M.

Result.—Destroyed at 7-30 A.M., on the 7th. Septr. 1897.

Time	M	E	M	E	M	E	M	E	M	E	M	E	M	E	M	E
Bowels.																
Urine.																
107°																
106°																
105°																
104°																
103°																
102°																
101°																
100°																
99°																
Normal Temperature of body																
98°																
97°																
Day of Disease																
Pulse.																
Resp.																
Date.																

Temperature (Fahrenheit)

Post mortem appearance of Buffalo No. 4 fed on dung and blood from a case of Rinderpest, and destroyed on the 7th September 1897.

Mouth.—Erosions.

Pharynx.—Erosions with brany deposits and gelatinous effusions.

Larynx and Trachea.—Normal.

Lungs.—Congested and emphysematous.

Heart.—Normal.

Stomachs.—Only the last stomach congested and the mucous membrane thickened.

Intestines.—Small intestine congested with croupous membrane, caecum was congested with numbers of croupous membranes. Large intestines were exanthamatous with fibrinous casts and Rectum with stripes and patches and the mucous membrane thickened.

Spleen and Liver.—Normal, and Gall Bladder venous congested the mucous membrane thickened with petiches.

Kidneys.—Slightly congested with serous effusion in and around.

APPENDIX VII.

DISEASE.

Rinderpest.

Notes of Case.

Name { *Buffalo.*

Case Book No. 5.

Infected from Bullock "A" with Rinderpest on the 29th August 1897.

Enough bile was found for about 40 injections, but only 14 were injected at Dumuria.

Series.—L K I—xiv.

Blood was taken and injected on 10th. at 8 A.M. into Bullocks K—2 & 10 as tests.

Dose.—20 c. c. m.

Date of Inoculation.

9th. Aug.'97 at 1-30 P.M.

Result.—Destroyed at ... A. M., on the 9th. ..., 1897.

August 29 30 31 1 2 3 4 5 6 7 8 9

Time	M	E	M	E	M	E	M	E	M	E	M	E	M	E	M	E	M	E	M	E	M	E	M	E	M	E	M	E
Bowels																												
Urine																												

Temperature (Fahrenheit): 107, 106, 105, 104, 103, 102, 101, 100, 99, Normal Temperature of body 98, 97

Day of Disease / Pulse / Resp. / Date.

Post Mortem Appearances of Buffalo No. 5, fed on dung and blood of Rinderpest.

Skin.—Eruptions around the teats and perinacium emphysema of subcutaneous areolar tissue.

Mouth.—Normal.

Pharynx.—Slight brany deposit.

Larynx and Trachea.—Normal.

Lungs.—Emphysematous and congested *anteriorly.*

Heart.—Ecchymosis on the endocardium of left ventricle.

Stomachs.—First three stomachs Normal and the fourth one considerably congested and thickened with 2 big erosions.

Intestines.—Small intestines congested and yellowish in places. Mucous membrane thickened and Peyer's patches enlarged. Caecum and large Colon slightly congested with streaks. Single Colon normal. Rectum slightly congested with stripes.

Liver.—Congested and gall Bladder congested with ecchymatic spots.

Spleen and Bladder.—Normal.

Appendix X

Test inoculations

DISEASE

Rinderpest

Notes of Case.

Name { K / L / H

Bullock

Was inoculated with 10 c.cm. bile from Buffalo No 3, on the 5th September 1897.

Received injected Subcut on 12th Sept. 10 c.cm blood from Buffalo No 3

7th day.

Date of inoculation

Bile 5th Sept. Blood 12th Sept.

Result – Immune.

Time.	E E E E E E E E E EM E EM MEMEMEME
Bowels. / Urine	
Temperature (Fahrenheit)	10, 10, 10, 10, 10, 102, 10, 10, 99, 97
Normal Temperat of body	
Day of Dis	
Pulse	
Resp	
Date	

Temperature (Centigrade): 42°, 41°, 40°, 39°, 38°, 37°, 36°, 35°

Appendix XI
Test injections

DISEASE

Rinderpest

Notes of Case.

Name { K / L / 16

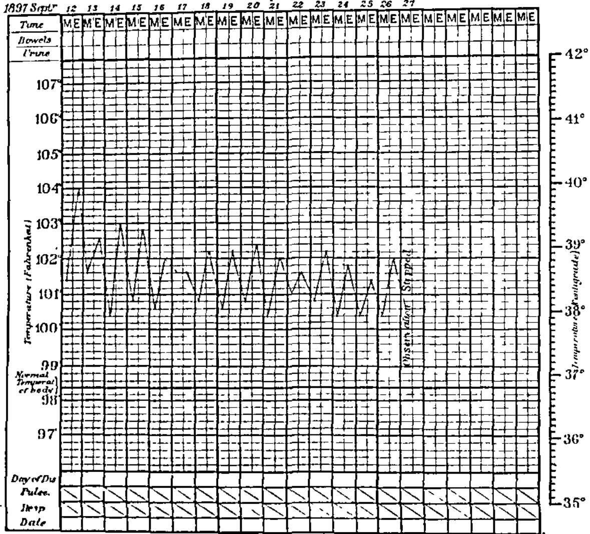
Bullock

Was inoculated with 20 c cm bile from Buffalo No 1 on 5th September 1897

Received subcut 20 c cm. of blood from Buffalo No 5 on 12th Septr 1897. 7th day

Date of inoculation.
Bile 5th Septr Blood 12th Septr

Result, Immune



VETERINARY CAPTAIN RAYMOND'S REPORT.

APPENDIX XII.

Post-mortem appearance.

Mouth—Excoriation of Buccal membrane, hard palate, dental pad, inside cheeks, lower lip, gums, under surface of tongue, soft palate and throat: the latter was much congested and discoloured.

Pharynx—congested and claret-coloured and excoriated.

Larynx and Trachea—lining membrane congested and discoloured in patches.

Heart—Pericardium discoloured in patches. Endocardium marked with spots of ecchymosis.

Lungs—both congested, particularly the right one, and emphysematous.

Liver—clay-coloured and somewhat enlarged.

Gall Bladder—mucous membrane marked with patches of congestion.

Kidneys—both congested.

Spleen—also congested and somewhat enlarged.

Abomasum—very much congested, the anterior half being of a leaden hue and the posterior claret-coloured with excoriation and patches of extravasation.

Omasum—Epithelium easily peeled off, etc., and the blood vessels enlarged.

Reticulum—mucous membrane congested and its epithelium easily removeable.

Rumen—Epithelium easily removeable and it contained a large quantity of amphistoma Conicum.

Small Intestine—contents were liquid, with large amount of viscid mucous and shreds; mucous membrane congested and marked with numerous patches of extravasation and several of the Peyer's patches ulcerated.

Large Intestine—mucous membrane congested in patches of scarlet colour and the contents were liquid with a large quantity of mucous casings and shreds.

Rectum—congested in patches and streaks.

Appendix XIII
Test inoculations

DISEASE

Rinderpest

Notes of Case

Name { K / L / I

Bullock

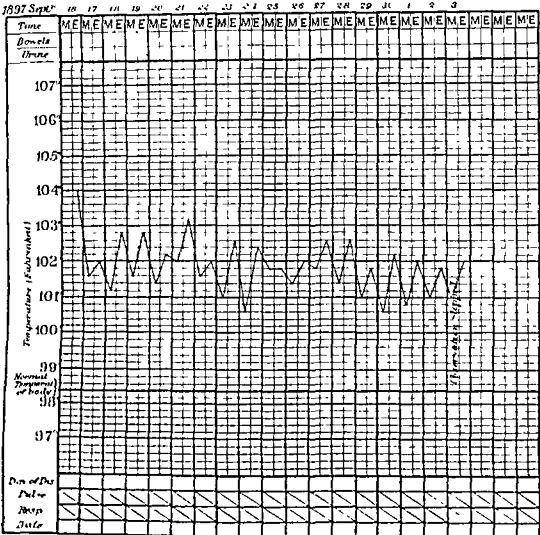
Was inoculated with 20 c cm bile from Buffalo No 1 on the 5th September 1897

Received injected subcutaneously 20 c cm virulent blood on 16th Sept 1897 [illegible] Belgaum [illegible] which died after 12 hours [illegible] of the blood

— 11th day —

Date of inoculation [illegible] Blood 16th Sept

Result immune



Appendix XIV
Test inoculations

DISEASE

Rinderpest

Notes of Case.

Name { *K.* *L.* *2* }

Bullocks

Was inoculated with 10 c cm bile from Buffalo No. 3 on the 5th September 1897

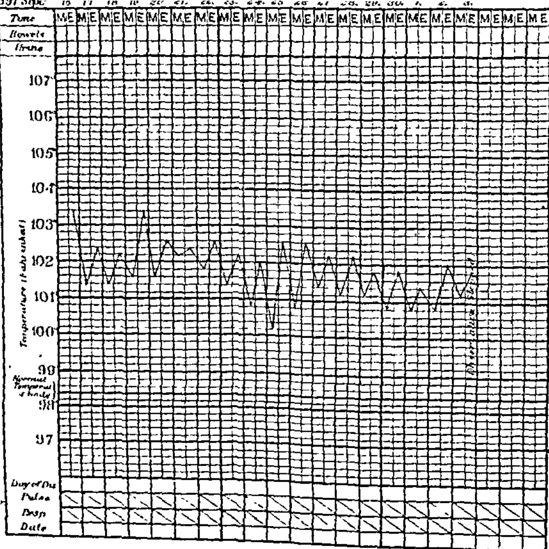
Received injected subcutaneously 20 c cm virulent blood on 16th Sept. 1897 and 0 c m Polyatchia andobtained from a severe case of Rinderpest which died 12 hours after removal of the blood —

— 11th day —

Date of inoculation

Bile 5th Sept. Blood 16th Sept.

Result — Immune.



REPORT of VETERINARY-CAPTAIN EVANS.

REPORT OF VETERINARY-CAPTAIN EVANS.

7. Veterinary-Captain Evans, Superintendent, Civil Veterinary Department, Burma, after carefully describing the various methods adopted by Professor Koch, states :—

"In conclusion, from what I have said, it may be gathered that I

any experiments until such time as I am satisfied that I may reasonably expect good results.

Professor Lingard at the Laboratory is, I fancy, the person best calculated to conduct experiments which are likely to afford the required information, as he has the time and facilities. I am strongly

be the case. When I hear that the protective method is successful, I have little doubt as to my ability to introduce it quietly, and in a short time to gain the confidence and assistance of the Burmans, in carrying the system out."

VETERINARY LIEUTENANT BALDREY'S REPORT.

VETERINARY-LIEUTENANT BALDREY'S REPORT.

8. Veterinary-Lieutenant Baldrey, Assistant Principal, Bombay Veterinary College, makes the following remarks, after careful consideration of the methods adopted by Professor Koch :—

After inoculation with rinderpest blood, the temperature in four days goes to 104: then rinderpest evinces the usual symptoms. As far as I can see from personal observation, this system cannot be *pronounced as an absolute certainty. One animal that I saw immunised*, contracted a mild form of rinderpest when inoculated with virulent rinderpest blood, and I think that a great number of animals should be tried in different parts of the country, before going any further than to say that this system is any more than experimental. Up to now there is nothing to guide us in proving how long the immunity lasts: and this is a matter which would take at least two or three years to prove: an immunity of a few months would be of no practical value. An attack of rinderpest from which an animal has recovered, is known to produce a certain degree of immunity, but animals have been known to get the disease two or three times and even then die. I think it essential that some experiment should be tried in the Plains—say at the various Veterinary Schools—under systematic isolative precautions, as the climate is very different to Muktesar, which is at an elevation of 7,700 feet; and a variety of conditions are necessary to prove its invariable efficacy.

Up to now these experiments in India are Laboratory ones, in a favourable climate and under the most favourable conditions, so I think it necessary that something should be done in the Plains, and [illegible] such as they [illegible] ow that if an [illegible] be immune [illegible] it has been [illegible] outbreak of rinderpest is absolutely essential to the carrying out of preventive inoculation, and that the bile from one dead rinderpest animal cannot be relied upon to do more than 10 (ten) animals, and that unless the inoculation be carried out by thoroughly competent men, it is more than probable that instead of rendering immunity, fresh centres of infection would be set up. I have said earlier in my report that the bile must be taken not later than seven days. This is because *the duration of the disease, from the rise of temperature, is only seven days*; *if an animal lives longer than that, it has overcome the disease* itself, so that it is very doubtful if bile taken after the seventh day, would be of use. This also requires experiments. I may briefly here explain how it is that rinderpest blood produces the disease, as they—both bile and blood—undoubtedly contain the poison of rinderpest. It is thus :—

[illegible] into the blood [illegible]

Immunising Cattle against Rinderpest. | OXEN.

VETERINARY-LIEUTENANT BALDREY'S REPORT.

"Bile when inoculated, immediately causes inflammation, and consequent swelling: this swelling, which is as large as a child's head, inhibits the power of surrounding blood vessels and lymphatics to absorb the poison, and the action of the animal secretions in the affected part, have such an effect on the poison, that it loses its power to produce the disease but retains sufficient vitality to produce immunity. Bacilli of all kinds may occasionally be found in the bile, but this is accidental; they having found their way in from the intestine. None of these bacilli have yet been found to be rinderpest: they are ordinary putrefactive germs. No bacillus of rinderpest has as yet been isolated.

[illegible] a very [illegible] cupied [illegible] of an [illegible] end. [illegible] food, the boots and clothes of attendants, is conveyed to any distance and for any length of time."

G. I. C. P. O.—No. 1415 R. & A.—5-7-98.—2225—P. M. M.

O. 590-94.

All communications regarding THE AGRICULTURAL LEDGER should be addressed to the Editor, Dr. George Watt, Reporter on Economic Products to the Government of India, Calcutta.

The objects of this publication (as already stated) are to gradually develop and perfect our knowledge of Indian Agricultural and Economic questions. Contributions or corrections and additions will therefore be most welcome.

In order to preserve a necessary relation to the various Departments of Government, contributions will be classified and numbered under certain series. Thus, for example, papers on Veterinary subjects will be registered under the Veterinary Series; those on Forestry in the Forest Series. Papers of more direct Agricultural or Industrial interest will be grouped according as the products dealt with belong to the Vegetable or Animal Kingdom. In a like manner, contributions on Mineral and Metallic subjects will be registered under the Mineral Series.

This sheet and the title-page may be removed when the subject-matter is filed in its proper place according to the letter and number shown at the bottom of each page.

NOTICE.

Future issues of this publication placed under either the "Special Veterinary" or "Special Forest Series" will not be included in the annual enumeration. Such papers are printed for Departmental purposes. Their unfortunate inclusion in the system of annual numbering has led recipients of the ordinary issues to think their sets incomplete.

The following pamphlets have already appeared as Special issues, and have not accordingly been furnished to the public:—

1894 . . . Nos. 8, 9, 10, 11, 13 and 15.
1896 . . . No. 8.

THE

AGRICULTURAL LEDGER.

1898—No. 6.

OROXYLUM INDICUM.

(SEEDS.)

[*DICTIONARY OF ECONOMIC PRODUCTS, Vol. V., O. 233-41.*]

DAMREE SEEDS.

THEIR REPUTED USE IN ALMORA AS A MEDICINE FOR CATTLE.

Review of Correspondence on the subject with notes giving results of an analysis of the seeds by MR. D. HOOPER

Other DICTIONARY articles that may be consulted :

Melia Azadirachta, *Vol. V.*, M. 363-93.
Oxen, *Vol. V.*, O. 551-94.
Pongamia glabra, *Vol. VI., Pt. I.*, P. 1121-37.



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OFFICE OF THE SUPERINTENDENT, GOVERNMENT PRINTING, INDIA.
1898.

Price 2 annas or 2d.

The objects of THE AGRICULTURAL LEDGER are:—

(1) To provide information connected with agriculture or with economic products in a form which will admit of its ready transfer to ledgers;

(2) To secure the maintenance of uniform ledgers (on the plan of the Dictionary) in all offices concerned in agricultural subjects throughout India, so that references to ledger entries made in any report or publication may be readily utilised in all offices where ledgers are kept;

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(4) To secure a connection between all papers of interest published on subjects relating to economic products and the official Dictionary of Economic Products. With this object the information published in the Ledgers will uniformly be given under the name and number of the Dictionary article which they more especially amplify. When the subject dealt with has not been taken up in the Dictionary, the position it very possibly would occupy in future issues of that work will be assigned to it.

THE

AGRICULTURAL LEDGER.

1898—No. 6.

OROXYLUM INDICUM.

(SEEDS.)

[*Dictionary of Economic Products, Vol. V.*, O 233-41.]

DAMREE SEEDS.

THEIR REPUTED USE IN ALMORA AS A MEDICINE FOR CATTLE.

A Review of Correspondence on the subject with notes giving results of an analysis of the seeds by MR. D. HOOPER

INTRODUCTORY.

The interesting information conveyed in the following correspondence throws fresh light upon a product which has hitherto received little attention at the hands of Europeans in India. The bark of **Oroxylum indicum** is much better known to the natives of India as a medicine than the seed, and has long been employed as one of the ingredients of *Dasamula* or ten drugs mentioned by Sanskrit writers. The bark is used for various complaints administered internally, but as an outward application it is equally beneficial. Rheede noticed the use of the bark as an application to wounds and fractures. Boiled in Sesamum oil the root bark is a remedy in otorrhœa, a muco-purulent discharge of the ear. The bark is also much used by the agricultural classes as an application to the sore backs of draught cattle; for this purpose it is ground to a paste with water and an equal proportion of turmeric, and rubbed on the part affected.

Oroxylum bark.

It is not very surprising then to find that the seeds have somewhat similar properties to the bark and are being used for like disorders as the following observations will show.

OROXYLUM indicum.	Damree Seeds, a Medicine

REVIEW of CORRESPONDENCE.

From J. G. Bellairs, Esq., Proprietor, Chowkooree Tea Factory and Dairy Farm, Berenag P.O., Almora, to the Reporter on Economic Products to the Government of India, dated the 16th December 1896.

Damree seeds.

I am sending you by Parcel Post paid to-day the seed of a plant known here as "Damree," and I shall be very glad if you can inform me of its botanical name. The tree is found at 3,000 feet and lower, and sheds its leaves in winter. The seed (pod) I have had to cut in half for the convenience of sending.

The flaxy seeds found inside the pod are the best cure I know of for ringworm in calves, one or two mixed with some finely ground *bhut** (Glycine hispida) and administered to each calf night and morning, will cure the worst cases of the disease known here as "Damrèe" also. Whether the disease was named after the plant or the plant after the disease I cannot say.

Seeds identified.

The seeds were identified by Dr. Watt as those of Oroxylum indicum, *Vent.*, a tree belonging to the Natural order BIGNONIACEÆ. Our correspondent was informed of the name of the seeds and at the same time was asked for further particulars regarding the peculiar veterinary use to which the seeds were put The following interesting reply was received in response to the request.

From J. G. Bellairs, Esq., Proprietor, Chowkooree Tea Factory and Dairy Farm, Berenag P. O., Almora, to the Reporter on Economic Products to the Government of India, dated the 13th January 1897.

Your letter of the 8th instant to hand yesterday, and I note that the tree known here as "Damree" is Oroxylum indicum. After sending you the pod I had come to the conclusion it was Bignonia indica from what K. L. Dey says in his book on indigenous drugs, and from Brandis' description of the tree.

Peculiar Cattle disease.

I am not wrong in saying the seed of the tree cures the disease known here as "Damree" for that I am quite certain of, but I may be wrong in thinking the disease is ring-worm. The disease is common amongst native owned cattle, but I never had a case in my herd until one year when I was given a Brittany bull and cow lately imported by Government. A calf was born about 3 months after arrival of the pair, and very soon after birth the calf got spots about the size of a 4 to 8 anna bit on the face, ears and neck from which the hair disappeared and which had a slightly red look. I was told the disease was "Damree," and that I should find a hard circle

* Otherwise known as the Soy Bean.—*Ed.*

REVIEW of CORRE-SPONDENCE.

about four annas in size on the roof of the mouths, and I was also told that probably all my calves would get the disease and sure enough all did. Natives said the seed of "Damree" was the cure, but none could then be got. These circles spread all over the animal till at last the calves look most peculiar. I washed with phenyle and gave sulphur internally, but could not see much benefit; I then continued the sulphur internally and applied it as ointment externally; paid great attention to keeping of the calves' houses clean, and once or twice a week either burnt sulphur or sprayed with phenyle, and in about 4 or 5 months the disease was beaten, but not before the worst cases had died. I was told that next year I might get the disease again in my calves, so I kept my eye on the houses and twice a month fumigated them, and in December laid in a stock of "Damree" seed. The disease did appear and on the first ring showing itself I did as the natives suggested and gave a seed or two with ground *bhut* (**Glycine hispida**) for a few days; few calves got more than 2 or 3 rings and these disappeared soon, and the calves not attacked, I presume from getting a few seeds, were never attacked. Now I do not fear the disease in the least, for directly it appears I dose every young animal with the seeds.

Usual remedies tried.

Damree seeds successful.

Veterinary-Surgeon Raymond was this way one year and I mentioned the disease to him, but could not show him a case, he said it might be ring-worm and so I called it that, but it may be something quite different

The calves attacked badly if not given "Damree," are covered with these rings which look exactly as if one had taken a metal seal and burnt the calf all over; the calves at first do not seem out of sorts, but as the number of rings increases they get thinner, have no spirits and the smaller ones will die; but calves of 6 to 9 months will generally pull through but they are miserably thin when over it.

I am at 7,000 feet and "Damree" or **O. indicum** grows at 3,000 feet or in the Ramgunga Valley 16 miles from this, and it is not distributed everywhere in the Valley. I know the tree is to be got about Ranibagh and Kalidungi below Naini Tal, and I will send your letter to Mr. F. E. G. Mathews, a very old resident and interested in arboriculture, etc., and I will ask him to send you down what you want. He will find 50 trees at Ranibagh, whereas I might ride 16 miles and

Distribution of Oroxylum.

REVIEW of CORRESPONDENCE.

walk 3 or 4 along the valley without finding 3 trees; when I want a few dozen pods it takes one of my men a week to get them.

No other part of the tree is valued in this district, except the seeds and they are only used for the disease known as "Damree."

Reference to Veterinary Department.

On the receipt of the above letter from Mr. Bellairs, the Inspector General of the Civil Veterinary Department was referred to on the subject of the disease of cattle known as *damree*. It was considered the wisest course to obtain the technical name and a professional description of the disease, and to ascertain the value of Oroxylum seeds as a curative agent. The tree is so very common all over India that any special virtue attaching to its products should be investigated and made generally known.

The Inspector General, Civil Veterinary Department, in reply to the enquiries made by this office, obligingly forwarded a note on the disease drawn up by his assistant, and it was pointed out that it was very unusual for a disease of this nature to be treated solely by internal remedies, as they generally yielded only to such strong *chemicals* as silver caustic and acids

From the Assistant to Inspector General, Civil Veterinary Department, to the Inspector General, Civil Veterinary Department,—No. 9, dated 14th April 1897.

Tinea tonsurans.

With reference to your letter No. 263 C., dated 27th February 1897, I have the honour to state that the disease "Damree" alluded to, is similar to the disease Tinea tonsurans, and which is very common among young cattle in England. It is caused by the fungus Tricophyton tonsurans. Its constituents are smaller than those of Favus, and it does not project as cups on the surface, simply invading the epidermal structures and constituting a fine powder on the epidermis. It affects young animals especially when exposed to damp, and with dirty skins, and is readily transmissible from ox to ox, or to man and other animals. It attains a greater luxuriance of growth in the ox than in man, and the disease, when first received by man from the ox, is so luxuriant that it has been described as specifically distinct.

Symptoms—Circular patches in various parts of the body, characterised by the absence of the hair the presence of vesica near the outer margin, and a scurfy condition of the central parts. Here and there in the ring may be seen a dry-looking hair, of a greyish

colour, somewhat twisted at the root, or the stump of a hair which has broken off. Magnin considers the true **Tinea** of the ox distinct from that of the horse, and terms it **T. decalvans** or **T. depilens** This he finds to be generally nearly three times the size of **T. tonsurans**, to give rise to more formidable symptoms when communicated to the horse by inoculation, and to induce a different condition of the affected hairs. In calves, the disease affects the eyes, ears, neck, withers, and limbs. REVIEW of CORRESPONDENCE.

Treatment.—These cases are usually treated with such remedies as Nitrate of Mercury, Nitrate of Silver or preferably Sulphurous Acid, but at the best the disease is difficult to relieve. It would be well to further test the seeds of **Oroxylum indicum** and communicate the results to the English Veterinary Journals.

The enclosures of the letter under reply are herewith returned.

Rev. A. Campbell, Manbhum, kindly furnished a supply of the seeds of **Oroxylum indicum** for chemical examination and experimental purposes. They are known in that district as *bana hatuk*. RESULTS of CHEMICAL ANALYSIS.

The seeds are thinly discoid, flat, and very light buff coloured. They are winged and translucent (hyaline) all round except at the base, and the largest measure 3 in. by 1½ in. When powdered they have a yellowish colour and a peculiarly rancid or oily odour, and a bitter and acrid taste.

Chemical Composition.—The powdered seeds exhausted with various solvents, and the moisture and ash at the same time estimated gave the following proximate composition— *Composition of seeds.*

Moisture	3·65
Oil	20·34
Resin and bitter principle	12·96
Mucilage and albumen	20·54
Fibre	32·71
Ash	9·80
	100·00

The oil was green in colour, bitter in taste and fluid above 70°. The bitterness was due to a principle found also in the spirit extract of the seeds which had a distinctly yellow crystalline appearance. This principle was insoluble in water and gave a peculiar reaction with caustic alkalies which consisted in assuming a red colour passing

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REVIEW of CORRESPONDENCE.

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REVIEW of CORRE-SPONDENCE.

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OROXYLUM indicum. | Damree Seeds, a Medicine for Cattle.

RESULTS of CHEMICAL ANALYSIS.

into a green on exposure to the air. This yellow substance is no doubt the same as that which was detected in the bark of this tree by Messrs. Naylor and Chaplin, and called Oroxylin (see *Pharm. Journ.*, September 27, 1890, *Pharmacographia Indica*, Vol. III, p 16).

Composition of Oroxylin.

Werner (*Beitr. Z. Kenntn. neuerer Drogen, Diss* Erlangen, 1896) since the discovery of oroxylin has made a minute anatomical examination of the bark and has performed an elementary analysis of its bitter principle. He found 67·49 per cent. of carbon and 4·38 per cent. of hydrogen. At the same time he tried the physiological action of oroxylin.

Physiological tests.

A frog after a subcutaneous injection of 150 m. gm. intimately mixed with water, exhibited no perceptible change. A rabbit treated in the same manner showed a rise of 1° of temperature in 3 or 4 hours, the respiration was accelerated and on the other hand, there was a decrease of the pulsation from 170-160 to 130.

Seeds a Famine food.

However active the seeds may be when medicinally applied, their potency is much reduced by heat and boiling. In Balrampur, *during the famine of 1897, the seeds of* Oroxylum *were parched*, ground into flour and made into bread The agent of this district also reported that on some occasions the seeds were eaten raw (*Innes.*) It would thus seem that there is nothing present of a decidedly poisonous nature in the seeds, and this opinion is supported by physiological tests made by Werner.

Bitter oils of Melia and Pongamia.

Bitter oils are much esteemed in India as applications for skin diseases. The oils of Melia Azadirachta and Pongamia glabra are widely used for these purposes, both on men and animals, and like many other remedies the nut of the seed is given internally while the oil is used as a lotion or liniment on the affected portion of the skin. Pityasis and other parasitic affections have been removed by applying the bitter oils above mentioned, and there is reason to believe that the yellow active principle operates in the same manner as chrysophanic acid and destroys the growth of disease.

Mr. Bellairs is quite satisfied with the results obtained in using *damree* seeds for skin affections in cattle, and although the remedy might not accord with the usages of modern veterinary science, the publication of the facts may induce others to try a simple remedy within the reach of every Indian ryot.

O. 233-41.

G. I. C. P. O.—No. 139 R. & A.—20-7-98—2,125.—B N. D

All communications regarding THE AGRICULTURAL LEDGER should be addressed to the Editor, Dr. George Watt, Reporter on Economic Products to the Government of India, Calcutta.

The objects of this publication (as already stated) are to gradually develop and perfect our knowledge of Indian Agricultural and Economic questions. Contributions or corrections and additions will therefore be most welcome.

In order to preserve a necessary relation to the various Departments of Government, contributions will be classified and numbered under certain series. Thus, for example, papers on Veterinary subjects will be registered under the Veterinary Series, those on Forestry in the Forest Series. Papers of more direct Agricultural or Industrial interest will be grouped according as the products dealt with belong to the Vegetable or Animal Kingdom. In a like manner, contributions on Mineral and Metallic subjects will be registered under the Mineral Series.

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* This sheet and the title-page may be removed when the subject-matter is filed in its proper place, according to the letter and number shown at the bottom of each page.

NOTICE.

Future issues of this publication placed under either the "Special Veterinary" or "Special Forest Series" will not be included in the annual enumeration. Such papers are printed for Departmental purposes. Their unfortunate inclusion in the system of annual numbering has led recipients of the ordinary issues to think their sets incomplete

The following pamphlets have already appeared as Special issues, and have not accordingly been furnished to the public :—

1894	. .	Nos 8, 9, 10, 11, 13 and 1.
1896	. .	No. 8.

THE AGRICULTURAL LEDGER.

1898—No. 7.

(Reprint from Assam Bulletin No. 4.)

PIPER NIGRUM.

(BLACK PEPPER.)

[*DICTIONARY OF ECONOMIC PRODUCTS, Vol. VI., Pt. 1., P. 811-20.*]

CULTIVATION OF BLACK PEPPER IN ASSAM.

A Note by MR BHUPENDRA CHANDRA BASU, *Assistant to the Director of Land Records and Agriculture, Assam, with an Introduction by* MR. D. HOOPER.



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(Food Substances.)

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2. Introductory Note by MR D. HOOPER

INTRODUCTORY.

In publishing the interesting note by Mr Bhupendra Chandra Basu on "Pepper in Assam," it would be well to preface it by a few general remarks on the cultivation of black pepper in India. The pepper vine (**Piper nigrum**, *Linn.*) is indigenous to the forests of Travancore and Malabar whence it has been introduced into Sumatra, Java, Borneo, Malaya and Siam. The earliest travellers to India observed the cultivation of the vine in Malabar and the important trade carried on in the spice between Europe and the ports of Calicut, Alleppy and Quilon on the Western Coast. (Habitat.) (Madras.)

A wild pepper was found by Dr. Roxburgh in the hills north of Samulcotta on the Eastern Coast. The plant, on account of its sexual peculiarities, was named **Piper trioicum**, but according to later authorities, it is now considered to be nothing more than the wild form of **P. nigrum**. The author of the "Flora of British India" remarked in 1886 that "our knowledge of the specific limits of **P. nigrum** are as vague as of its geographical."

In Bombay the only district in which pepper is grown to any extent is Kanara. The varieties are named *kari malisaru*, *sambar* and (Bombay.)

PIPER nigrum.

Cultivation of Black

INTRODUCTORY.

arsina murliga. The quality of the spice yielded by these three kinds of plants does not differ very materially, the difference consists in the crop the proportionate weight of which is greatest from the first named variety and least from the third. The pepper is fairly well established in the State of Mysore. In various parts of Burma the local demand for pepper, which is not very large, is said to be satisfied by its cultivation as a garden crop in villages, a system introduced by the Chinese.

Mysore.

Burma.

Bengal.

Bengal imports large quantities of pepper from the Straits notwithstanding the heavy production of the spice in the country. The exportation of pepper from the Straits exceeds at the present time that from any other country and its quality is much esteemed.

Comparative weights of peppers.

The general opinion of the trade is that Malabar pepper is superior in being the heaviest, and the merchant relies upon this test more than upon its appearance. Peppers are hence known as "heavy," "half heavy" and "light." Dr. Wynter Blyth in 1875 estimated the exact weight of 100 pepper corns belonging to different tradé samples. The following was the result:—

100 pepper corns of	Penang, weighed	.	6·249 grams.
" "	Malabar "	.	6·053 "
" "	Sumatra "	.	5·147 "
" "	Trang "	.	4·573 "
" "	Tellicherry "	.	4·507 "

The first two were bracketed together as standing first, Sumatra held the second place, and the last two the third.

Assam pepper Reg. No. 10701.

The Officiating Director, Department of Land Records and Agriculture, Assam, has kindly forwarded a sample of Assam pepper illustrative of Mr. Basu's paper. The fruits were smaller and more irregularly marked than the usual commercial samples. A weight test was taken of the pepper corns to compare their heaviness with other specimens. At the same time a sample of ordinary Bengal pepper from the Economic Gallery of the Indian Museum was tested with the following result:—

Compared with Bengal pepper Reg. No. 3018.

100 pepper corns of	Bengal, weighed	.	6·157 grams.
" "	Assam "	.	3·082 "

The Assam pepper was only half the weight of the Bengal which compared favourably with that of good commercial fruits. It is possible that in Assam the cultivators have not paid sufficient atten-

CULTIVATION

tion to collecting the crop as the fruit begins to ripen. If collected when too young or allowed to hang on the tree after they are ripe, the pepper corns deteriorate in appearance, solidity and value.

It is not perhaps generally known that black pepper is cultivated as a garden crop in certain parts of Assam. The writer of the article on black pepper (Piper nigrum) in Dr Watt's *Dictionary of Economic Products* does not mention its cultivation in Assam; the only reference made in that article to Assam is to the effect that black pepper is doubtfully indigenous in the forests of this province.* I have found black pepper being grown in many villages in the Sibsagar district. It is chiefly found in some villages in mauza Gadhuli Bazar in the west of the Sadar sub-division. In this mauza *is a village Jalukgaon, named after the Assamese word for black* pepper. It is currently reported to have been the chief seat of pepper cultivation at one time. In Lower Assam the cultivation of black pepper is reported to be unknown. On the other hand, a little of it is to be found in Sylhet and on the southern slopes of the Khasi Hills bordering on that district. The crop is not, however, cultivated to any appreciable extent in any part of Assam. It is usually cultivated to supply the cultivator's own requirements, and what is left over after meeting his own wants is sold. The aggregate quantity of black pepper produced in Assam is indeed very small, and very little of it finds its way to the market. Assam continues to derive its supply of this spice chiefly from Calcutta, although there is no apparent reason why it should not grow the whole of it, and have more to spare.

A garden crop occasionally met with.

'Black pepper village.'

Not extensively cultivated.

Supplies mostly imported.

The black pepper vine is known in Assam as *gách jaluk*, and the spice locally produced as *guti jaluk* or *bári jaluk*, the latter name owing its origin to the fact of the spice being the produce of an Assamese *bári* or homestead, as distinguished from the usual commercial product, which, from its being sold by shop-keepers, is known as *golar jaluk*. Only one variety of cultivated black pepper is known in Assam. The Assam pepper seed is slightly smaller in size than the foreign product which comes through Calcutta. The

Vernacular.

Assam pepper smaller than the foreign article.

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* From enquiries I have made, black pepper does not appear to occur in the wild state in any part of the Assam Valley, but an allied species (P. longum), the *pipal* or long pepper, is so found.

PIPER nigrum.	Cultivation of Black

CULTIVATION

indigenous article is, however, more pungent, perhaps because it is more fresh, and, therefore, commands a higher price in the local market.

Trees employed as a support for the vine.

In Assam, the black pepper vine, like the betel vine (Piper Betle), is usually grown on betel-nut trees (Areca Catechu), mango (Mangifera indica), jack (Artocarpus integrifolia), and other garden trees are occasionally utilised for the purpose; but of all trees the betel-nut is regarded as the most convenient and suitable for raising *pan* and black pepper. It is planted immediately around the raiyat's homestead, and receives more manure, labour and care than any other tree or crop grown by him. The rearing of betel and pepper vines in association with this tree entails but little additional labour on the cultivator. The plucking of the leaf in the case of *pán* and of the ripe berry in the case of black pepper is also very convenient when these are grown on the betel-nut trees, as by the simple application of a ladder every part of the vine can be easily and quickly reached.

Betel-nut tree:

Advantage of.

Manner of rearing the vine.

The pepper vine is raised either from suckers which spring up from underground roots or from shoots from the stem. Shoots when used, are bent down into the ground to strike root before they are severed from the mother plant. The young plants are taken out with their roots at the beginning of the rains, and transplanted at the foot of the trees on which they are intended to grow. Generally, only one plant is put down at the foot of each tree. The slender stem of the young vine requires in the beginning to be carefully tied on to the supporting tree. As it grows up, it throws out from each joint numerous bunches of short claw-like adventitious roots, which penetrate into the soft outer bark of the supporting tree, and give the vine a firm hold upon the latter. New shoots and suckers continue to appear, and growing up the tree, envelope it in the course of a few years with a dense mass of foliage.

Later treatment of black pepper and betel-nut very similar.

The subsequent treatment of the black pepper plant cannot be distinguished from that of the betel-nut tree, with which it is mostly associated. Like the latter, it requires to be very liberally manured. Cowdung and household refuse are the only manures in use in Assam and of these as much is given as the cultivator can afford. The manure is applied at the end of the rains and at intervals all through the cold weather. It is simply heaped up round the base of the tree on which the vine grows, and affords nutrition to both. The

CULTIVATION — Manuring.

manure heap serves the further purpose of protecting the root from cold and drought. To keep in the moisture in the manure heap pieces of the thick juicy bark of a plantain tree are [illegible] the base of the tree and renewed from time to time. A [illegible] plantation, whether *pân* or pepper be grown there or not, must be hoed and cleared once in the year at the close of the monsoon [illegible], a careful cultivator would repeat the operation thereafter until the rains again set in as often as he could spare time and labour for the purpose. The ground should be kept as clean and free of jungle as possible at all times of the year. In May, the manure heaps are levelled down and spread over the ground, otherwise they would absorb too much moisture and cause the roots of the vine to rot.

Hoeing and weeding.

The pepper vine is very susceptible to drought, which often proves fatal. Rain and fog in the cold weather cause the leaves to fall off, and are consequently dreaded by the cultivators. The plants then remain bare until the first warm showers of April, when new leaves re-appear. Hailstorms are a frequent source of injury to black pepper and other crops in Assam. Some damage is also caused by a species of caterpillar which feeds on the leaves of the pepper vine. When it appears, it is destroyed as far as possible by hand-picking.

[illegible] unfavourable to the plant. — Insect pest.

The black pepper vine begins to bear in from three to five years after planting, and continues to yield for at least twenty years. In every plantation, there are usually one or more vines which neither flower nor fruit. These are called *mati* or males, and the rest which bear fruit are known as females. The vine flowers in May and the berries are plucked in December. They are gathered when just beginning to ripen. If allowed to ripen fully they fall off and are picked off by birds. Pepper is cured in Assam in two different ways. If intended for the cultivator's own use, the berries would be boiled in water for a few minutes in order to soften the husk, which would then be removed by rubbing the berries over a bamboo basket. The spice so prepared is of a whitish colour, and more pungent than the kind prepared for the market. For this latter purpose, the berries are simply dried in the sun after boiling, and allowed to retain the husk, which assumes a black colour, and gives the black pepper of commerce its distinctive name.

Longevity. — Unproductive vines. — Seasons of flowering and harvesting. — Curing. — Two methods.

PIPER nigrum.

Cultivation of Black Pepper in Assam.

CULTIVATION

Yield.

The produce of a vine varies with its age and size and the character of the season. The highest outturn that can be obtained from a single vine is said to be about three seers of dry cured pepper; the average yield is commonly reported to be about one seer for each vine in a plantation.

Prices.

The retail price of Assam black pepper varies from 10 annas to a rupee per seer, and the wholesale price from R17 to R20 per maund. An acre of betel-nut plantation can hold about 500 trees, and if each tree had a pepper vine on it, the annual yield of pepper alone from the plantation might amount to over 12 maunds, valued wholesale at R200 to R250.

G. I C. P. O.—No. 82 R. & A.—20-7-98.—2,225 —B. N. D.

All communications regarding THE AGRICULTURAL LEDGER should be addressed to the Editor, Dr. George Watt, Reporter on Economic Products to the Government of India, Calcutta.

The objects of this publication (as already stated) are to gradually develop and perfect our knowledge of Indian Agricultural and Economic questions. Contributions or corrections and additions will therefore be most welcome.

In order to preserve a necessary relation to the various Departments of Government, contributions will be classified and numbered under certain series. Thus, for example, papers on Veterinary subjects will be registered under the Veterinary Series; those on Forestry in the Forest Series. Papers of more direct Agricultural or Industrial interest will be grouped according as the products dealt with belong to the Vegetable or Animal Kingdom. In a like manner, contributions on Mineral and Metallic subjects will be registered under the Mineral Series.

This sheet and the title-page may be removed when the subject-matter is filed in its proper place, according to the letter and number shown at the bottom of each page.

NOTICE.

Future issues of this publication placed under either the "Special Veterinary" or "Special Forest Series" will not be included in the annual enumeration. Such papers are printed for Departmental purposes. Their unfortunate inclusion in the system of annual numbering has led recipients of the ordinary issues to think their sets incomplete.

The following pamphlets have already appeared as Special issues, and have not accordingly been furnished to the public.

1894 . . . Nos. 8, 9, 10, 11, 13 and 15.

1896 . . . No. 8.

(Agricultural Series No. 25.)

(Food Substances.)

THE

AGRICULTURAL LEDGER.

1898—No. 8.

SACCHARUM:

(SUGAR AND SUGARCANE.)

[*DICTIONARY OF ECONOMIC PRODUCTS, Vol. VI., Pt. II., S. 126-40.*]

CULTIVATION OF SUGARCANE IN THE BOMBAY PRESIDENCY.

Note by MR. J. W. MOLLISON, *Deputy Director of Agriculture, Bombay Presidency, with Descriptions of Varieties of Sugarcane by* MR. MOLLISON *and* DR. J. W. LEATHER, *Agricultural Chemist to the Government of India.*

Other PAPERS that may be consulted:

The Agricultural Ledger, 1895, No. 13; 1896, No. 19; 1897, No. 3.



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CULTIVATION.

CULTIV.

The crop is cultivated in almost all parts of the Presidency and on a greater variety of soils than any other irrigated crop It adapts itself to almost any description of soil if drainage is secured by a pervious sub-soil or by artificial means A water-logged condition of soil is perfectly f-tal to successful cane cultivation. In other respects any description of il of fair depth suits one or more of the many varieties cultivated roughout the Presidency.

Soils suitable.

2. The varieties may be broadly grouped into two types, but there o numerous gradations between the two extremes:

Differen types.

(a) Thick, juicy, soft kinds which ordinarily require copious irrigation frequently given.

(b) Thin, very hard, less juicy kinds which require lighter irrigation at longer intervals.

General distribut of the c in the P sidency.

Ahmadabad and of Bassein and richer alluvial loams of the iat excellent crops of varieties almost continuously irrigated om wells and the cane is rotated with other garden crops such as ginger, urmeric, elephant's foot (*Surans*), yams, potatoes, sweet-potatoes, groundnt, plantains and betel-vines.

Cane in Gujrat.

4. In the Surat District sugarcane is not confined to soils of the ove description only. It is also grown on black soil, slightly tinged ith brown, about 4 feet deep, with a deep substratum of yellow earth hich consists of an intimate mixture of sand, clay and lime. The subil is fairly pervious to water. Cane is planted in such soil in artificially

SACCHARUM: Sugar.

Cultivation of Sugarcane in the

CULTIVATION.

embanked fields which also grow rice, or on higher drier land; but in either case there is always an interval of several years, usually 4 to 6, between two successive cane crops. Thick soft and thin hard varieties are often grown mixed on such land. It is not clear what advantage there is in growing the two kinds mixed, except when a border of a thin hard variety on the headlands surrounds the soft succulent variety. In this case it is currently believed that less damage is done by jackals and pigs. These pests are supposed to sample the hard cane on the headlands and finding it hard or not very sweet they pass on to a field with a soft succulent variety. Very often the two types are mixed indiscriminately all over the field. The same practices are also common in the Southern Marátha Count[illegible] The Surat Dist[illegible] [illegible]iety of soil and considerable [illegible] It is therefore not surprising [illegible] found in general cultivation and at least six of these are different from any found in the Deccan or the So[illegible] [illegible] loured that they c[illegible] Presidency. These [illegible]

Cane in Southern Marátha Country.

5. In the Southern Marátha Country, cane is grown to a large extent on the favourably situate low-lying brown or red-brown laterite soils which also grow rice, and, where good perennial irrigation facilities exist, also grow many other garden crops. On this class of land, also on medium black soil, cane is grown at intervals of 3 to 5 years. A cane of peculiar colour is here in common cultivation It has alternate longitudinal stripes of purple and green. Similar cane is sparingly cultivated in Khándesh and in the Nira valley (Poona District), but not elsewhere in the Presidency as far as I know. In the Southern Marátha Country the general style of sugarcane cultivation is not so advanced as in some districts.

Cane in the neighbourhood of Poona.

6. The most suitable soil for cane in the neighbourhood of Poona is black or mixed black, got from decomposed trap It is a stiff clay loam $2\frac{1}{2}$ to $3\frac{1}{2}$ feet deep, resting on *murum*, which is shaly limestone very pervious to water. This combination of soil and subsoil secures good natural fertility associated with good natural drainage. Only one variety of cane "Pundia" is grown near Poona. It is a particularly good variety and poss[illegible] [illegible] districts surpass or equa[illegible] [illegible]r. The cultivation of P[illegible]

Period of growth.

[illegible] 12 months' crop. Some varieties [illegible] has been heavily manured with a [illegible] maturity in perhaps 11 months, whilst a crop treated with a slow-acting manure may take 12 or 13 months to ripen. Again, a crop which is repeatedly top dressed with manure continues to grow longer and probably also yields better than a crop grown with the same amount of manure applied entirely before plantation. Ratoon cane ripens in less time than newly planted cane. In the neigh-

CULTIVATION.

bourhood of Poona cane planted late in March or early in April under canal irrigation is often allowed to stand over two monsoon seasons or for 18 months. Very often this p[illegible] the cane deteriorates, the extra price that [illegible] ordinary season) more than [illegible] for canal water is not much and there are no other extra expenses worth considering.

Seasons of planting.

8. Cane is planted in different localities at different seasons. In Ahmadabad, Kaira and Baroda, it is planted in May or early in June. The soil is of sandy character. White ants are very destructive on this class of land, particularly whilst the cane is young. The white ants do not do much harm during the monsoon to sugarcane, because on dry crop areas there is much vegetable growth at this season which supplies the white ants with food and the pest being widely distributed over large areas, the damage done is not particularly noticeable; therefore if the cane is planted in May it practically escapes damage whilst young. In the Surat District, also in the Southern Maratha Country, most of the cane is planted in November and December, but the season may extend to February. In the Poona District, February and March are considered the best months to plant. The season of planting depends somewhat upon local conditions. Generally speaking any season is suitable for planting except the hot weather. Young shoots suffer considerably from the hot sun, and a check received at this time from this cause or in fact from any cause is not afterwards recovered.

Propagation and method of planting.

9. The crop is propagated from sets, sometimes, as in Gujarát, by planting whole canes. The sets consist of pieces of cane generally about a foot long. Each set has usually three eye-buds, sometimes more, and then the set may be 15″ to 18″ long. When sets are planted beds are generally previously formed. The sets may be planted at the required distance apart in pits dug out with a small pick and 3 to 4 inches deep. One set is planted in each pit. The pits are in straight rows. The sets when carefully covered with soil are 4 to 6 inches apart in the rows and the rows 2 feet distant from each other. The beds are left level. This practice is common in Baroda. Water is given immediately after planting. Sometimes three or four sets are planted together in a pit, each pit being about 6″ deep and 12″ to 15″ square. The pits are about 2 feet apart from centre to centre. The cane then grows in clumps which stand up well in heavy wind or rain and which if bound round by dead leaves are not easily much damaged by jackals or pigs. The beds in which the clumps stand are left level. In the Southern Marátha Country it is customary, after the field is well prepared and manured, to plough it into ridges and furrows and, after watering, trample in the sets in the furrows. When the soil dries, the harrow or light plough is used to level the ridges over the planted sets and to work the land smooth and friable, so that when the cane sends up shoots,

SACCHARUM: Sugar.

Cultivation of Sugarcane in the

CULTIVATION.

these may be earthed up with the plough which is worked between the rows and forms furrows which serve as water channels for temporary irrigation. Subsequently beds are formed for regular irrigation, but in the case of hard varieties of cane requiring little water the surface is left level, the rows not being earthed up and the irrigation water is led over the field in the best way the cultivator can. This is not a desirable method, but when adopted in order to economize irrigation water as much as possible grass is spread over the surface and a fine layer of earth is put on the grass. This conserves moisture and therefore fewer waterings are required. In the [illegible] District the following is a common method of planting. Cane [illegible]
The sets are placed [illegible]
done in February, [illegible]
beds at all. [illegible]
planting. [illegible]

[illegible] serve as water channels for
[illegible] east slope, generally either the

[illegible] plough is used. The canes are
[illegible] inclined backward direction
[illegible] imbedded in the soil in the
[illegible] ation is facilitated by a man following the plough and trampling each cane *into the furrow as it is* pushed through the hole in the plough. The seed rate is calculated in lengths of 6 *hāth* [illegible]
per acre. Ve[illegible]
planting is of [illegible]
cultivators of the districts where this method is practised think it is most expeditious; *but this conclusion is wrong*. Many of the eye-buds are destroyed in passing the cane through the plough. Planting is commonly done in this way on black soils in the Surat District. If the plough is carefully guided the [illegible]
inches apart. After pl[illegible]
porary shallow beds, and [illegible]
As soon as the soil drie[illegible]
soil to a depth of about 3 inches. The sets are planted *below* this level and are not disturbed by the light plough. This light ploughing may be done twice. It kills weeds and leaves the surface soil loose and friable so that when the rows of young shoots are well up, they can be earthed up and beds can be easily formed in the ordinary way for regular irriga-[illegible]
[illegible] weeks or two months after
[illegible] 15 waterings are given
[illegible] land only 9. Deep black soil is, of course, very retentive of moisture and the cane being planted

CULTIVATION.

deep is favourably placed for moisture; still the practice of withholding water for a period of two months after plantation is by no means common It is generally conceded that at least the soft succulent varieties of sugarcane on almost any class of land, if grown from sets, require frequent light irrigation until the young shoots are well up.

Deep planting advantageous.

10. There is no doubt that [illegible] cane deep except on very reten[illegible] firm hold of the soil and the ca[illegible] heavy crop is not likely to be lodged by rain or wind. If planted deep in dense heavy soil germination is interfered with; at least cane will not germinate evenly if planted in this way on such land.

The Mauritius system of planting.

11. The Mauritius system of planting is, I believe, advantageous on any description of moderately free working soil. In this system pits, a foot sometimes more in depth, are dug about a yard apart in each direction. 2, 3 or 4 sets are planted in each pit and covered carefully. If the pits are deep they should not be filled up level with the surface until the young shoots appear above ground. Beds are formed for irrigation. Recently introduced Mauritius varieties do well when planted in this way, and it is probable that such Indian varieties as freely tiller would also succeed; but experimental trials are necessary.

Cane usually grown at intervals of several years.

12. In most districts of the Presidency sugarcane is rarely grown on the same land at shorter intervals than 4 to 6 years. Nowhere except in the Poona District is cane grown continuously for several years and in no other district is ratooning practised to any appreciable extent.

Ratoon cane.

13. A ratoon crop is one grown from the root stocks of the previous crop. There is clear evidence from the experiments at Mánjri that it is risky in the Poona District to take more than one ratoon crop. If new cane is planted on clean land, as of course it ought to be, there is little difficulty in keeping the new cane free of weeds particularly if the crop is heavy. It is not so easy to keep the succeeding ratoon crop quite clean. In the third year it is well nigh impossible, however careful the tillage [illegible]

[illegible] e and the second ratoon crop gets [illegible] e at all. It is quite likely that [illegible] cane and the first year's ratoon [illegible] without any direct application. Ratoon cane grown in this way would probably pay, even though a poor crop, because the cost of manure is by far the heaviest item in the cost of cultivation. On the other hand, deep-rooted grasses and other weeds

MANURING.

might get thoroughly established. The cost of cleaning and fallowing would be heavy. The profit from first ratoon is greater than from new cane. The preparatory tillage for the former is trifling. There is no expenditure for sets or for planting. Less irrigation and less manure is required.

I tabulate below outturn &c. results from first and second year's ratoon grown on comparative plots at Mánjri (Poona). The plots were equally manured to secure fair comparison. Rather heavy dressings of manure were given. In ordinary practice less manure would probably have been given to the first year's ratoon and certainly to the second year's crop.

First year's ratoon.

Manure	Weight of manure per acre	Weight of cane stripped and topped per acre	Outturn of *gul* per acre	Cost of cultivation per acre	Value of produce per acre
	Tons	lbs	lbs	Rs a. p.	Rs. a. p.
Safflower and ground-nut cake	3 3	68,030	7,689	320 10 0	126 10 0
Poudrette	22 65	73,580	8,055	324 14 0	447 8 0

Second year's ratoon.

Manure	Weight of manure per acre	Weight of cane stripped and topped per acre	Outturn of *gul* per acre	Cost of cultivation per acre	Value of produce per acre
Safflower and ground-nut cake	3 3	38,510	4,095	292 4 0	227 8 0
Poudrette	22·65	31,530	4,010	301 14 0	224 7 0

Possibly if a much lighter dressing of manure had been given to the second year's ratoon as in ordinary practice the crop would have paid fairly well.

Cultivation in the Poona District.

14. Cane is grown almost continuously under canal irrigation in the Poona District. Occasionally the land is fallowed and rested for few months, and when thoroughly clean, a green manure crop of *San* (**Crotola-** [illegible] This crop is everywhere recog- [illegible] A green manure crop of *Kulthi* [illegible] the Deccan a good prepara- tion. Ground-nut before sugarcane is considered good practice if the [illegible]

paratory crop is a green manure crop of *San*. The *San* should be [illegible] thickly in June or July (about 70 lbs. seed per acre) and ploughed in when 3½ to 4 feet high. The crop, if [illegible] It enriches the surface soil with a mass of c[illegible] therefore leaves the soil open an[illegible] tions can be done quickly and well. If no green manure crop has been grown

MANURING

the land is allowed to lie waste during the monsoon. This is objectionable, because grasses and other weeds get established and subsequent tillage and cleaning operations are expensive. The field is deeply ploughed in November with a large eight-bullock plough, an acre being covered in about 4 days. The soil is turned up into huge clods and is allowed to weather before it is cross ploughed. One or two subsequent ploughings in December improve the tilth considerably. Most of the clods break up into smaller nodular pieces and the soil becomes easily moved to a depth of about 10 inches. I may note that I have been able to accomplish the ploughing operations for sugarcane with Ransome's Turn Wrest plough quite as effectively as with the best pattern of indigenous plough and at considerably less cost for manual and bullock power. I advocate the use of the Turn Wrest plough for sugarcane and other garden crop cultivation; but for ordinary dry-crop cultivation I cannot conscientiously urge that this plough or any other non turn-furrow plough is as good as the best indigenous implements. After thorough ploughing the surface is levelled with a log harrow and clods a [illegible]
or thick short stick. Then [illegible]
manure are most commonly
say 30 tons of either per acre
[illegible] but usually
given before
castor cake,
karanj cake, fish manure or other concentrated manures

Nitrogen in early stages of growth.

15. It has been proved by the Manjri experiments, which will be referred to in detail further on, that certain manures
effective for sugarcane than ot[illegible]
ant constituent of manures for
able condition. The experime[illegible] not absolutely prove, that nitrogen in this form was absolutely essential to feed the young shoots during the early stages of growth. The sugarcane set itself contains very little on which the young shoot can feed. Therefore in the case of land in low condition the manures to be applied before plantation should be such [illegible]
poudrette, fish manure an[illegible]
yard manure, which has [illegible]
thoroughly decayed befor[illegible]
act more effectively and quickly.

What is the most economical dressing of manure for cane.

16. It has yet to be proved what is the most economical dressing of nitrogen that should be given to produce the best results. Dr. L[illegible] has shown by analysis that even a heavy crop of sugarcane does not take up more than 100 lbs. of nitrogen per acre, yet if all the manure is applied before plantation, as it ordinarily is in common practice, at least 400 lbs. of nitrogen per acre must necessarily be given for the best results.

IRRIGATION.

borders gives support to the cane so that it does not readily lodge. Moreover, the *Sheri* and castors yield good returns. Both plants grow to a height of some 15 to 20 feet in a year. The young *Sheri* branches are pruned and sold as fodder for milk goats and the trees give poles useful for roofing huts. The value of the produce from castors is also considerable. Sometimes to prevent lodging, cane is tied up. This operation must be carefully done to be effective. Canes from different roots should be tied, about six canes together loosely but securely with a band of dead leaves about 4 feet from the ground.

Trashing and wrapping.

24. Cane is trashed by removing all dead side leaves; thus air gets freer access and no doubt the crop is benefited. Wrapping the cane in its own dry side leaves is a costly operation which, however, probably pays where jackals and rats are very destructive. Jackals will not do much harm to wrapped cane if there is unwrapped cane conveniently near.

Irrigation and amount of water actually given for cane in Poona District.

25. After July or August in the Poona District cane requires no further attention except watching and careful watering. Irregular irrigation spoils the quality of the crop. It causes in soft juicy varieties splitting of the cane. The land is first flooded as the sets are planted and thereafter two or

Subsequently

interval in th

in the rains

averages about 30 inches. I have found by actual measurement that

12 months, in addition to the rain-

30 inches of rainfall, the crop being

a year. Therefore the water given

2½ to 3 inches of rainfall or approxi-

This is the quantity of water taken by an ordinary cultivator when he supplies himself from the canal. He would use less, probably to the advantage of his crop, if he drew the water from a well. We proved by actual experiment that more frequent lighter irrigation was preferable, *i.e.*, that a considerably heavier crop was got by irrigating 34 times during the year, giving in all water equivalent to 50 inches of rainfall in addition to the rainfall (30 inches). The extent of irrigation necessarily depends upon various circumstances. The thin hard bamboo varieties require much less water than the soft thick succulent kinds. In deep moisture-holding black or clay soils the interval between waterings in the fair season may be much longer than on soils of lighter description. In the sandy and light loam soils of Northern Gujarát, irrigation for soft cane is necessary every 5th or 6th in the hot weather and every 7th or 8th day in the cold weather. In contrast to this it may be noted that soft varieties, grown in the Surat District on embanked rice fields with deep soil retentive of moisture, if planted deep with a plough in moist soil in November, do not need water until the

DISEASES.

following February. Cane planted after November requires to be watered in January to as[illegible] between February and the [illegible]d in the monsoon, but two [illegible] rains in September-October [illegible]

Subordinate crops.

[illegible]

used as a green vegetable The stalks are cut green and therefore give much better fodder than that from a dead ripe crop. The *guvár* beans are also plucked green whilst the uprooted stalks are broken up by hand and with the leaves are left on the ground to serve as a green manure. Onions are grown from transplanted seedlings raised in a separate seed-bed. They may reach maturity before the sugarcane quite shades the ground. If they do not, it does not matter as they are quite marketable at almost any stage of growth. Melons and cucumbers are grown from seed planted here and there, but more particularly on the headlands. These plants make very rapid growth in a heavily manured sugarcane field. Tobacco is planted along the water courses and on the *bándhs* of the water compartments and takes about five months to come to maturity after the seedlings are transplanted. If the sugarcane, meantime, makes rapid progress the tobacco will not come to much.

DISEASES OF SUGARCANE

White ants destructive. Castor-cake as a preventive.

27. On sandy or light soil white ants are often very destructive. They attack the sets, the roots and the stems. Castor-cake used as manure is believed to keep white ants away. In Gujarát a common practice is to put a quantity of pounded castor-cake in a reservoir near a well. The irrigation water is made to flow through this reservoir. The cake gets soft and pulpy and an extract is carried by the irrigation water to the crop. In a few days the manurial value of the cake becomes exhausted and the spent cake is removed and thrown in the common manure pit. It is quite probable that this is an effective method of using castor-cake or perhaps any other cake as manure and the extract has fully as much effect in keeping white ants away as cake directly applied. It is questionable whether the cake becomes really exhausted by a few days' steeping, yet it may be so, for a somewhat analogous effect is well known by gardeners, *viz.*, that if fresh cowdung or horse-dung is steeped in water for several days, a liquid manure is produced which is extremely effective for roses and other plants in pots.

Salt for white ants.

28. Salt is also used as a preventive for white ants. The method of application is simple. It is tied in a cloth or sack mixed with assafœtida and hung at the head of the water channel and gradually gets dissolved in flowing water.

SACCHARUM: Sugar.

Cultivation of Sugarcane in the

DISEASES. Aphides on sugarcane.

29. Sugarcane is subject to several blights, known by various vernacular names, but all due to Aphides which increase rapidly especially in cloudy weather. Their presence is always accompanied by sticky matter on the leaves. These insects feed on the juices of the plant and thus exhau
effect
of 2
or ag
gallons of water and apply to the affected foliage with a spraying machine.

Scale insect.

30. A species of scale insect is common and when it exists to any extent, does considerable harm. An observant cultivator will detect the pest early. All affected leaves should be removed, and burnt, and the pest is thus at once checked.

Sugar borer.

31. The sugar borer, **Diatræa Saccharalis**, (vern. *Gabra*) often does an immense amount of harm, and yet damage by this insect can be very easily checked, if proper measures are taken in time. The pest usuall ... germinated, and the fi ... hering of the uppermost ... can be easily pulled out ... talk is found quite rotten with an offensive smell. A number of small white grubs are always present, and in large numbers if there is much rottenness. These are not the cause of disease, but harmless larvæ of small black or brownish flies, which follow the borer. The true cause of the mischief, the larvæ of the sugar borer, is seldom found. The round hole, by which it entered, may be seen, but when there is much rottenness at the core, the borer has probably gone to another cane. If, when the first sign of withering is seen, the affected cane or shoot is cut close to the ground and slit up, one or more borers will be found in a tunnel made in the solid cane. Professor T. H. MIDDLETON, late of Baroda College, describes the sugar borer thus:—

Remedies for sugar borer.

... urn all affected shoots ... The caterpillars are ... If no remedial treatment is adopted the insects will run through many generations in a single ... l; not only so, but the canes ... used for sets for re-planting. The sugarborer also attacks *jowár* and maize, but the moth is so sluggish

DISEASES.

in its movements that a field cleared of the pest as described above is not likely to be re-infected by insects coming from a distance.

A root parasite.

33. Sugarcane like *jowár* and some other cereals is subject to attack by a vegetable or root parasite **Striga lutea** (*Tarli* Deccan, *Agio* Gujarát). The *Agio* of Gujarát appears to have fleshier leaves and stems than the *Tarli* of the Deccan, but they are clearly botanically very much the same if not identical. The parasite is found thriving close to the stems of cane, or of *jowár*. Its fibrous roots entwine round the roots of the crops named, and check their growth. The parasite grows rapidly, and the only way to save the crop is by constant weeding. *Agio* belongs to the natural order **Scrophularineæ**. It is found abundantly in grass *kurans* (pasture lands), and therefrom doubtless finds its way to arable land in the dung of animals. It survives without a host; but it can be carried in the host plant. In proof of this, I noticed one particular variety of cane, on the Surat Farm this year (1897), badly affected at an early stage of growth. Other varieties in other adjacent beds were not affected. If once established in highly manured sugarcane land, it thrives amazingly. In irrigated land it flowers and seeds at all seasons, and is, therefore, extremely difficult to eradicate.

Smut.

34. Sugarcane is subject to smut which is probably caused by the same species of **Ustilago** as causes the smut, so common in ordinary cereals. Apparently the disease only attacks the flowering rachis, and if [illegible] the crop, [illegible] al to find [illegible] vers; but [illegible] introduced into India, generally flower freely. I have only observed smut in the thin hard or bamboo varieties, and its effect is most curious. At the Poona Farm cane propagated from sets became affected with smut when three months planted. The affected flowering stalks were premature growths. In the ordinary course no infloresence would have been produced for 10 to 12 months after plantation. The presence of disease spores apparently forced the premature growth of the infloresence in order to provide a suitable host for the disease. The source of infection was obscure; the crop from which the cane sets were got had not been observed to have been affected. *Sets from this variety, as well as sets from* [illegible] in the same way as seed grain, as a preventative is obviously inapplicable; and the only remedy appears to be to remove and burn all affected shoots.

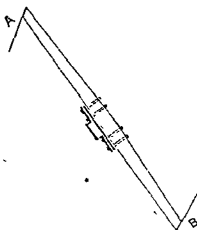
HARVESTING.

Tests of ripene

35. It is difficult to judge accurately by the eye when sugarcane is ripe. Frequently a cane-grower tests the ripeness of his crop by a trial boiling. If so many measures of juice give a satisfactory weight of *Gul*,

CRUSHING.

The draught pole has, sometimes, at its centre an iron piece fashioned as per marginal drawing. This iron piece is keyed to the squared part of the shaft of the central roller, so that the central roller gets direct motion from the draught pole, as it is turned by a pair of bullocks, attached at A, and another pair attached at B. When the mill is adjusted for work, the rollers should be perfectly vertical, and so close together, that it is hardly possible to see through between two adjacent rollers.



Cane crushing.

39. The cane is passed twice through the mill, first between the middle and one outside roller and back between the middle and the other outside roller. ly, two men, one on either side of the whole cane, the other feeding pole is fixed on the shaft high enough to pass over the heads of these men as they sit in the usual native position at work. Two men or boys drive the work-cattle, and it is the duty of one or other of these to remove the crushed refuse as it collects, a basketful at a time, and throw it down evenly in an open space to dry, so that it can subsequently be used as fuel in the boiling process. A man prepares the canes for the mill by removing the green tops and cutting long canes into two shorter lengths for more convenient handling by the man that feeds the mill. Three or four pieces of canes are passed between the rollers simultaneously. Iron mills of the above pattern can, when properly adjusted, express up to 73 per cent. of juice from soft succulent varieties of cane. The quantity approximately 3,700 lbs If the c day is short, but long if the cane is lower plate is turned up about $1\frac{1}{2}''$ i is expressed, collects here and flows through an opening into a receiver placed underground. This receiver holds eleven *gharas*, so that it has to be twice emptied to supply juice sufficient for one boiling. The bottom plate of the mill and the top of the underground receiver are practically flush with the ground. Close-fitting loose boards are placed over the receiver. The man who feeds the half-crushed cane sits on these boards and notices that the receiver does not overflow with juice. The juice from the underground receiver is emptied into two iron drums placed

Crushing.

near the evaporating pans. It should be strained through cloth or through a wire gauze sieve to remove impurities. When these drums are quite full the juice is emptied into the evaporating pan. The two drums just hold enough (920 lbs) juice for one boiling.

The old-fashioned wooden mill.

40. Iron mills have taken the place of wooden mills in all parts of the Presidency. In Gujarát and in Dhárwár only a few of the cane cultivators own iron mills. The use of these will extend as the advantages become known. Their advantages, both as regards economy in labour and effectiveness at work, cannot be questioned; still the old wooden mill is very much in evidence. A common belief prevails that the wooden mill gives purer juice which can be made into finer *Gul* than the ironmill; but this is mere fancy. The true reason why the wooden mill keeps in favour is that it is made locally and the parts can be replaced or repaired as they go wrong. The mill costs Rs. 35 to 50. It is slow at work and constantly liable to accident, causing suspension of operations until the village carpenter arrives to repair it. The iron mill is an adaptation of the wooden mill. The latter has three wooden rollers about [illegible] These are placed side by side [illegible] of each cylinder is cut out [illegible] s attached to the central roller [illegible] iron mill. The middle roller [illegible] he wives The male screw of the central roller fits into the female screws of the side rollers, and communicates motion to the side rollers. The cane has to be repeatedly passed between the rollers before all the juice is expressed. The mill, though clumsy and heavy to work, extracts the juice fairly well. A wooden mill in good working order extracts as much as 65 per cent. juice from soft succulent cane.

GUL-MAKING.

The boiling process

41. The evaporating pan in most general use is about 7 feet in diameter and 9" to 12" deep. It is made of stout sheet iron which in pieces of the required shape are rivetted together. The pan has four circular handles each about 4" in diameter, welded or fixed to the lip of the pan at equal distances apart. When it is necessary to place the pan on the furnace or remove it therefrom, two stout poles are passed each through a pair of opposite handles. Ten or more men lift the pan and carry it steadily by means of these poles. Two pans are required, one is used for evaporating, the other as a cooler into which the hot *Gul* is emptied when boiling is complete.

42. The oven or furnace is of simple construction. A trench is dug about 18 inches wide, 8 feet long, gradually getting deeper towards one end until a depth of some 5 feet is dug out. A circular excavation is now made at the deep end with a diameter of 4 to 5 feet This circular chamber and the trench is the source whence the oven furnace is provided with a draught of air and also prov[illegible]

GUL-MAKING.

the ashes. The ashes which collect one day are removed before work begins the following day. The furnace which is partly excavated and partly built up is of larger diameter than the ash chamber. It is nearly the same diameter as the evaporating pan, being about 6 inches less, so that the evaporating pan fits neatly on the top of the furnace. The ash chamber being of smaller diameter than the furnace, a ledge is left between the two on which corrugated iron sheets are laid to form the bottom of the furnace. There is a grating in the centre about a foot square. Ashes escape through this and the draught air is admitted. The furnace is built up with sun-dried bricks in a circular form inside to a height of about 3½ or 4 feet. The brick work is banked up all round with earth. The front is built up square and a small opening is left about 20″ × 14″, through which the fire is fed with fuel as required. The lip of the oven is plastered smooth so that the [illegible] s, [illegible]



Preparing the pan.

43. The pan is prepared before use by rubbing it well inside with leaves of the castor oil plant and then with a paste of *Udid* (**Phaseolus radiatus**) flour and *Til* (**Sesamum indicum**) oil, the object being to prevent the *Gul* burning and sticking to the pan. The *udid* flour pre-

GUL-MAKING.

serves the oil so that the pan only requires re-coating occasionally. It is not required oftener than every two or three days

Professional boilers.

44. The sugar boilers are professionals in the Poona District and pretend that special knowledge is required to make good *Gul*. There is no mystery in the art further than that a regular heat should be maintained and that all impurities should be skimmed off during boiling.

Fuel.

45. The dry side leaves and the dry refuse of crushed cane usually provide sufficient fuel, especially so in the case of a good crop. If extra fuel is required, the husk of safflower or the stalks of *Tur* **(Cajanus indicus)** or of cotton or light brush-wood are commonly used.

Feeding the fire.

46. The fuel should be of such kind that the fire can be continuously fed by small quantities thrown into the furnace at a time.

Skimming.

47. As soon as the juice begins to boil, impurities rise to the surface in the form of a scum. This should be removed. Skimming is done with a long-handled wicker work ladle which allows the pure juice to drain away but retains the thick scum. This ladle is also used to agitate the syrup vigorously to prevent boiling over, when the fire is too hasty.

Impurities removed.

48. The impurities are most effectively removed if a mucilagenous extract from the *Bhendi* **(Hibiscus esculentus)** plant is mixed with the juice when boiling begins or at a later stage.

The boiling process.

49. It usually takes about 2½ hours to boil a panful of juice to the proper consistence When evaporation is nearly complete, the mass acquires the yellow-brown colour of *Gul*. It heaves and bubbles rather than boils and should be kept in constant movement by a wooden hoe moved backwards and forwards in all directions. The syrup is boiled sufficiently when a little put in cold water hardens quickly. The pan is then removed from the furnace A blessing is invoked and the contents emptied into the cooling pan. Here the *Gul* is stirred repeatedly with a wooden hoe as it cools. When it is cool enough it is put before it hardens by means of a wooden spatula into a cloth which lines a cylindrical hole in the ground. Here it sets into a hard block or *Dhep*. It is removed next day and is ready for sale. If the blocks are pale in colour and hard the *Gul* is considered of good quality.

Comparative trial with different mills.

50. In January of this year (1898) a comparative trial was arranged for, in the Dhárwár District by the Ag
the capabilities of the Poona three-r
time-honoured wooden mill, and wi
mill made at Bellary (Madras), which has recently come more or less into use in the Dhárwár District. The opportunity was also taken to demonstrate the Poona method of sugar boiling.

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I believe that successful demonstrations of this kind are impressed much more forcibly and beneficially on the minds of ordinary agriculturists if conducted by native officers, provided the men so employed have tact, shrewdness, and thorough practical knowledge of the work in hand. The overseer of the stock farm and sugarcane experiments at Mánjri, who is a Kunbi or agriculturist by caste, was sent to conduct the trial. With him was also sent a professional sugar-boiler of the Poona District, also a man accustomed in the Poona District to feed fuel to the fire during the boiling process. These men could, with their own hands, build a fire-place and other necessary construction of a *Gurhâl* according to the Poona plan. The work referred to, and the boiling process require a certain degree of expertness which is very easy to demonstrate by actual practice, but which would be difficult to describe by tongue or pen.

A three-roller mill and all the apparatus necessary for a complete outfit for sugar-boiling were sent to *Hirekerur*, *Dhárwár District*. The cultivation of sugarcane is very extensive in this place. The apparatus had been in use for two seasons [illegible] fairly be gauged by the fact [illegible] and all the apparatus at cost p[illegible] was decided not to press for fr[illegible] exception of the mill (the freight charges on which would be trifling) the rest of the apparatus can be locally made, now that a proper pattern is available. The freight charges on all the apparatus amounted to Rs. 70, whilst those on the mill only would be under Rs. 20.

The tabulated statements which are given below show that the Poona [illegible] does in the Poona [illegible] pared with the Bc[illegible] vork is considera[illegible] xpressed by the Bellary mill which the Poona mill could have expressed, represents a loss of one pound of *Gul* per every 100 lbs. of cane crushed, and in the case of the wooden mill 2½ lbs. of *Gul* per 100 lbs. of cane. Forty tons per acre of cane is not a heavy crop, and not more than average for the Poona District, and we may take it that the Bellary mill as worked at Hirekerur left unexpressed juice equivalent to 800 lbs. *Gul* per acre of good crop, whilst the wooden mill probably left 2,000 lbs. *Gul* per acre of good crop. The cost of the Poona mill could thus easily be recovered in a single season, owing to its more effective work. The question may be raised whether the respective mills were properly adjusted for effective work. The Poona mill certainly was, because the percentage of juice expressed is the percentage ordinarily obtained from good cane. We may assume that the [illegible] ork to the best of their [illegible] y mill possibly, if he [illegible] The officer in charge

COMPARATIVE TRIAL WITH DIFFERENT MILLS.

was fully instructed regarding the manner in which the trials should be conducted, and had express orders to prevent any attempts to work the cattle in any of the mills beyond their ordinary pace, whilst the trials were in progress, and generally to see that the trials were complete in every respect.

Comparative statement showing the work of the three sugarcane mills tried at Hirekerur (Dhárwár).

Name of the Mill	Weight of Cane	Weight of Juice	Weight of Gul.	Percentage of juice to Cane	Percentage of Gul to Cane	Value of Gul produced in a day.	Loss of juice in a day taking Poona mill as the standard	Value of *Gul* or juice thus lost per day.
	lbs	lbs.	lbs oz	lbs.	lbs	Rs. a. p.	lbs.	Rs. a. p.
Dhārwār wooden mill with three rollers.	2,313	1,335	299 0	56·97	·12·76	13 0 2	238 (57·7 Gul).	3 7 7
Bellary iron mill with three rollers.	2,187	1,395	313 8	63·79	14·33	18 14 2	92 (20·6 Gul).	1 3 10
Poona iron mill with three rollers.	3,892	2,640	528 0	68·00	†13·60	57 2 11	.	...

The cost of labour for each mill per day for cutting, carrying and crushing cane and sugar-boiling is shown below, also other details (labour being charged at ordinary hiring rates).

Name of the Mill.	Weight of Cane crushed	Time occupied in crushing.	Weight of Juice obtained	Weight of Gul obtained	Number of boilings per day.	Labour for cutting, carrying crushing, and boiling, &c.			Remarks
						Work people.	Bullocks.	Amount	
	lbs.	H. M	lbs.	lbs oz.				Rs a p.	
Dhārwār wooden mill with three rollers.	2,313	9 50	1,335	299 0	3	5 men 2 boys	4	2 8 0	Man 4 annas per day. Boy 2 annas per day. Bullock 4 annas per day.
Bellary iron mill with three rollers.	2,187	9 21	1,395	313 8	3	5 men 1 boy	4	2 6 0	
Poona iron mill with three rollers.	3,883	8 33	2,640	528 0	3	9 men 2 boys	8	‡4 8 0	

The first mill is a wooden mill with three vertical rollers fixed side by side in a wooden frame, similar in construction to the mill described in paragraph 40. To work this mill one man, one lad, one boy, and four bullocks in relays two at a time, are required; the man to feed the mill,

* Scum not removed during boiling process † Scum removed during boiling process.

‡ The work-people had not got experts at the work like Poona cultivators, and the work done in a day with the Poona mill at Herekerur was about ⅞ths of that usually done by contract work near Poona. Four boilings per working day are always done at Poona with manual and bullock labour equal to that used at Hirekerur, contract wages being, for bullocks and men, Rs. 5 per day.

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the lad to pass the cane a second time through the mill and the boy to drive the bullocks.

The following are the measurements of the different parts of the mill :—

Diameter of the middle roller	... ...	1′ 6″
Do. of one side roller ...	... ...	1′ 3″
Do. of the other side roller	.. ...	1′ 1″
Length of each roller ...	... ...	3′ 6″
Length of the beam (draft pole)	... ...	8′ 4″

This mill at ordinary speed makes 162 revolutions per hour.

The second mill is a three roller iron mill. Two of the rollers are of the same size, and the third is smaller in diameter. They are set vertically in a triangle. This mill is very useful for small sugarcane areas. The cane, as it passes through, is double squeezed. One man only, therefore, is required to feed the mill. A boy or lad can drive the two bullocks. Four bullocks are required for a full day's work, in relays, two at a time.

The measurements of the different parts of the mill are as under :—

Diameter of the larger roller	... 0′ 8″
Do. smaller roller	.. 0′ 4½″
Length of the roller ...	... 0′ 10″
Do. beam (draft pole)	.. 8′ 0″

This mill at ordinary speed made 166 revolutions per hour.

The Poona mill described in paragraph 38 costs Rs. 120, the Bellary mill Rs. 125, and the wooden mill any price between Rs. 35 and Rs. 50, depending upon size &c.

The pan commonly used in the district has a diameter of 5′ 2″ at the top and is 11″ deep at the centre and is saucer-shaped.

[illegible] out 4 ozs. of [illegible] is poured in [illegible]. The scum, [illegible] so dark-coloured jagri is produced. When the comparative trials were commenced people visited every day in numbers, and always asked why no lime was used. They noticed the bright colour of the jagri made by the Poona method, and thought it was due to the non-admixture of lime with the juice, whereas it was really due to the removal of the scum by skimming. To prove that the reason assigned by the people was wrong about 2 ozs. of lime was mixed to a pan and the jagri was in no way discoloured.* Then the people began to say "there is much loss in throwing away the

* [illegible]

scum." An experiment was therefore made at a cultivator's *Gruhál* with the following results :—

Boiling	Cane crushed.	Juice obtained.	Jagri obtained.	Percentage of Juice to Cane.	Value of Jagri per Rupee	Value of Jagri.
	lbs.	lbs	lbs. oz		lbs.	Rs. a. p.
Scum not removed	729	465	104 8	14·4	16·6	6 4 3
Scum removed ..	729	465	97 8	13 3	14·2	6 13 2

The above statement shows a loss of 7 lbs. of jagri when scum was removed. But this was made good by the higher rate obtained when sold. The people were satisfied, but I am not at all sure that quality is always appreciated. In some parts of the Presidency neither the wholesale buyer nor the consumer pays much attention to quality. In parts of Gujarát no skimming is done and there, bright well prepared Poona jagri is objected to because it lacks flavour.

The only other point on which the people argued was, as regards the hardness of the respective blocks of jagri, and which would keep longest during the monsoon. The question was left in abeyance as it could not be settled, offhand, like other objections.

. As soon ... a minute ... ade in the ground, 3 feet long, 2 feet 3 inches wide, and 4 inches deep. The *pack* or pit is sided with planks. The next day, the jagri in the *pack* has set hard, and is cut into 12 pieces each 9″ square, and weighing from 5 to 7 lbs. While cutting the *pack*, there is generally about 4 or 5 lbs. of broken jágri which the owner keeps for home use. The Dhárwár cultivator shows poor ingenuity in solidifying his *Gul*. The Poona method described in paragraph 49 is much better; so also is the Madras plan of using a wooden mould divisioned into cells; but the Gujarát plan of storing in earthenware pots is best of all.

The dry leaves of sugarcane are not used for boiling jagri. They are sold for thatching. Firewood and sugarcane refuse are used for boiling.

In Dhárwár, there is not a special man to attend to the boiling as at Poona. The man that feeds the fire also looks after the boiling. The juice for one boiling weighs about 465 lbs., just about half the quantity usually boiled in the Poona boiling pan.

51. In the Poona District the *Dheps* are sold by the *Palla* of 120 *sers* or 240 lbs. By custom 246 lbs. go to the *Palla*. Generally throughout Gujarát it is customary to put *Gul* into earthenware pots. When sold a deduction of 5 *sers* per maund or 12½ per cent. is allowed

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on account of the pots; but usually the actual weight of pots exceeds this allowance. There is a decided advantage in storing *Gul* in this manner, because if soft there will be no loss of treacle by drainage. Moreover, the *Gul* can easily be protected from flies and other insects. When sold by retail one side of the pot is broken off and the *Gul* is easily removed in small quantities. In Khándesh the potters who provide the earthen pots claim the crushed cane (megass) as their perquisite. They extract by lixiviation a small amount of inferior *Gul* and use the residue for burning pots and bricks.

COMPARATIVE MANURING EXPERIMENTS AT THE MÁNJRI EXPERIMENTAL STATION NEAR POONA.

Results of two years' experiments recorded.

52. These experiments were begun in 1894-95, but the plots were not manured in that year in accordance with any definite standard and were, therefore, unequally manured. Moreover, after a year's experience it was found expedient to modify the original scheme considerably. The results which I shall record are those of 1895-96 and of 1896-97. The former crop was newly planted cane, the latter was a ratoon crop grown from the root stocks of the previous crop.

53. *Objects of the experiments.*—To test the comparative values of such manures as are within the reach and means of ordinary cultivators and when the effects of the various manures have been clearly demonstrated then to determine whether two or more of the manures used cannot be judiciously combined so as to secure economy.

In both years the various manures each contained 500 lbs. per acre of nitrogen. The percentages of other elements of value are known, and in years to come it may be found that marked differences between the crops of the various plots may be traced to the value of elements other than nitrogen. If this can be done the value of the experiments will be enhanced and information be gained which will indicate how two or more manures should be mixed to give the most paying results.

Several edible oil-cakes tested as manures in comparison with those ordinarily used.

54. The manures which the cultivators of the Poona District ordinarily use are [illegible] om the Thána coast, castor cake a [illegible]. In both years we have tested a[illegible] with the foregoing several edible cakes which are now used for feeding cattle in India or are largely exported. These cakes can be bought in Poona at a considerably cheaper rate per ton than the castor and *Karanj* cake now so extensively employed as manure. DR. LEATHER's analysis shows that the edible cakes contain much higher percentages of nitrogen (the most valuable con[illegible]) than the manure cakes, and our tests indicate that [illegible] yed with economy and success as manure. [illegible] use of edible cake as manure is surely a wasteful practice. My answer to that is that it is surely a much more wasteful practice to feed milch and work cattle with cake and other concentrated food and permit the solid excrement to be burnt as fuel and the

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urine to be lost. If edible cake is used directly as manure, something is returned to the land which will help to maintain fertility. It might be urged that work and other cattle can only be kept in efficient condition if partially fed on cake or other concentrated food and, therefore, it becomes necessary to show that the increased production of cane through the use of edible cakes as manure more than compensates for the cost of stimulating food given to cattle. This is difficult to show in black and white. At the same time, the fact that an application of 3 tons per acre of edible cake is capable of producing as much as 12,000 lbs. of crude sugar per acre as food for men and 12,000 to 15,000 lbs. of green tops as fodder for cattle proves that edible cake is put to a good use when used as manure. I admit it would be put to a better use if fed to cattle provided the solid and liquid excrements are properly conserved and used as manure.

No definite relationship between the commercial value of manures and their value according to chemical analysis.

55. There is no definite relationship between the values of the manures as determined by chemical analyses and their commercial value. It is certain that the cane-growers of the Poona District, though much above the average in intelligence, fail to recognise the difference in manurial value of the manures they use.

56. The results of our comparative manure experiments are not only intended to prove which manures in given quantity are most effective for sugarcane, but also which manures are cheapest. It may be that when a particular manure is shown to be cheap its extended use will soon make it dear, but there will be an advantage to somebody

Farm-yard manure probably the cheapest manure a cultivator can use.

57. Farm-yard manure and cattle-dung are charged at full local [illegible] four times as high as [illegible] crops are not grown. [illegible] -d strict rates, cattle-dung will be proved much the most economical manure that a cultivator can use, because considering its chemical composition it is much the cheapest. The value for manure will vary with the food given to the cattle and the care with which it is preserved with litter and urine. Properly saved farm-yard manure will not, as our experiments indicate, be weight for weight as valuable as pure dung, but then the manure pit will be filled much more quickly with the former than the latter. The dung from poorly nourished animals is considered by ordinary cultivators just as good as that from those highly fed. Both descriptions are with equal readiness used as fuel. In almost all districts the value of cow-dung as fuel is as great or greater than its value as manure because wood is scant and dear. In the Poona District this is notoriously the case. Therefore it is not surprising that a cultivator of cane sells the dung of his cattle as fuel and buys poudrette, oil-cake, &c., for his crop.

Quick-acting manures give the best results especially in the case of new cane.

58. Although the quantity of each manure applied in the *Comparative Manure Series* contained 500 lbs. of nitrogen, there were very great differences in outturn between the various plots. This was particularly noticeable on the new cane, not to such an extent with ratoon.

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Ratoon cane owing to its greater root development is able to get nutriment from a slow-acting manure much more effectively than new cane does in the early stages of growth. At any rate the differences between the plots of new cane were, in a great measure, due to variation in the activity and effectiveness of the various manures. Ratoon cane springs into active and vigorous growth at once and at the early stage there was no appreciable difference between its various plots; but in the case of new cane it was clear that some of the manures acted far more actively than others. How far the action was due to the presence in the manures of elements other than nitrogen, can only be conjectured at this stage of the experiments. The practical fact remains that certain manures, *i. e.*, fish manure, poudrette and some oil-cakes had quicker action than other oil-cakes and much quicker action than cowdung or farm-yard manure.

Slow-acting manures caused uneven germination.

and

in g

Oil-cake made in country *ghâni* extremely quick-acting.

60. Oil-cakes as made in Europe are generally considered to be slow in their action as manure. Oil-cakes as made in the ordinary country *ghâni* are extremely quick in their action. In India oil-seed as ordinarily pressed is ground up into an impalpable powder as the oil is expressed. The oil-cake is consolidated during the process, but before again powdered, and I have no doubt the disintegrate into impalpable powder when moisture of the soil. It is easy to under- of division will very soon show preparing cake in Europe and in is quite different. The seed is crushed, but not into fine particles. The crushed seed is cooked or steamed. Thus the oil freely escapes from the oil cells. The cooking of the crushed seed would of necessity convert the albuminoids into a much ly. The s reason- oil-cake does not become available as plant food nearly so soon as that in oil-cake made in the ordinary country *ghâni*.

Hydraulic essed cake in action reasons given.

61. The results of the comparative manure experiments which I tabulate below under Series A and Series B will be better understood from the above explanations.

Period of growth.

62. The new cane was cut in $11\frac{1}{2}$ to 12 months after plantation. Those plots which germinated well and were dressed with quick-acting manure ripened soonest. The ratoon cane was cut 10 to $10\frac{1}{2}$ months after the previous crop was reaped.

Manures applied partly before plantation, partly as a top dressing.

63. In 1895-96, the manure was applied three-fifth before plantation in March and two-fifth in July. In 1896-97, the ratoon plots were manured with three-fifths of the application in May and two-fifths in July. It is not customary to give manure to a ratoon crop until it has made considerable growth.

Bombay Presidency. *(James Mollison.)*

Comparative Manures, Series A, 1895-96 and 1896-97.

Plot Number.	Manure	Year of Crop	Manure per Acre	Nitrogen per Acre	Cost of Manure per Acre	Weight of Cane stripped and topped per Acre	Weight of Tops per Acre	Weight of Gul per Acre	Percentage of Gul to Cane	Remarks.
			Tons	lbs	Rs a	lbs	lbs	lbs.		
2	Safflower cake.	1895-96 New cane	3 3	500	169 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] a rich dark green colour Irrigated 27 times
		1896-97 Ratoon cane.	3 0	500	185 13	71,760		8,433	11 7	Harvested 15th, 16th January 1897 Crop looked vigorous and healthy throughout. Irrigated 16 times
3	Bassia cake (*Mhowra*) Bassia latifolia.	1895-96 New cane	8·6	500	323					
		1896-97 Ratoon cane	8 3	500	209 7	68,820	..	7,895	11 5	Harvested 15th January 1897, regular germination Healthy growth throughout. Irrigated 10 *times.*
6	Cotton-seed cake	1895-96 New cane	7·1	500	316					
	Crushed cotton-seed	1896-97 Ratoon cane.	6·6	500	362 1	73,645		9,050	12·3	Crushed cotton-seed was substituted for cotton-seed cake, the latter not being obtainable It is believed that in districts where cotton is grown, and where the seed is very cheap, it will probably be found an economical manure for sugarcane grown in the same districts The dark-green colour of the leaves of the cane was conspicuous in comparison with some of the other plots of the series Reaped 12th, 13th January 1897 Irrigated 16 times The p[illegible] paid for the cotton seed is [illegible] dearer in Poona than in *growing districts*

SACCHARUM: Sugar.

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Cultivation of Sugarcane in the

Plot Number.	Manure.	Year of Crop	Manure per Acre.	Nitrogen per Acre	Cost of Manure per Acre.	Weight of Cane stripped and topped per Acre.	Weight of Tops per Acre.	Weight of Gul per Acre.	Percentage of Gul to Cane.	Remarks.
			Tons.	lbs	Rs a	lbs	lbs	lbs		
7	Fish manure.	1895-96 New cane	2 9	500	158 12	91,				
		1896-97 Ratoon cane	2 7	500	161 7	76,5				
8	Castor cake.	1895-96 New cane	5 0	500	203 10	90,770	13,010			
		1896-97 Ratoon cane	6 2	500	202 11	73,430				
9	Karanj cake (*Pongamia glabra.*)	1895-96 New cane	6 6	500	280					
		1896-97 Ratoon cane	5·3	500	203					
12	Poudrette.	1895-96 New cane	22 3	500	150					times
		1896-97 Ratoon cane	20 1	500	179 13	56,105	...	7,410	13 4	The crop was somewhat disappointing Germination was satisfactory, but the crop at no stage of growth had the thriving appearance of the previous year's crop Harvested 8th and 9th January 1897 Irrigated 16 times
13	Cattle dung from ordinary fed cattle.	1895-96 New cane	25 1	500	160 4					

SACCHARUM: Sugar.

MANURING EXPERIMENTS.

Bombay Presidency. *(James Mollison.)*

Plot Number.	Manure.	Year of Crop	Manure per Acre	Nitrogen per Acre	Cost of Manure per Acre	Weight of Cane stripped and topped per Acre	Weight of Tops per Acre.	Weight of Gul per Acre.	Percentage of Gul to Cane	Remarks
			Tons.	lbs	Rs a.	lbs	lbs	lbs		
13	Cattle dung from ordinary fed cattle	1896-97 Ratoon cane	15·0	500	127 12	70,115		8,150	11·6	This plot gave much more satisfactory results under ratoon cane than in the previous year Owing to the well-known lasting effect of cattle dung the crop probably benefited by the unexhausted residues of the same manure applied during the two previous years Harvested 7th and 8th January 1897 Irrigated 15 times
14	Cake-fed cattle manure mixed with urine and litter.	1895-96 New cane.	20·0	500	184 14	53,790	11,175	6,950	12·9	The remarks made against Plot 13 apply equally to this plot Crop planted 30th March 1895, harvested 20th to 24th March 1896 Irrigated 27 times
		1896-97. Ratoon cane	25·0	500	142 12	62,205		7,870	12·6	Ratoon crop more satisfactory than the previous year's crop of new cane It is, however, clear that there are more satisfactory manures for sugarcane than either farmyard manure or cattle dung Crop harvested 7th January 1897. Irrigated 16 times
15	Safflower and groundnut cake	1895-96 New cane	3·4	500	162 0	63,000	10,060	7,900	12·4	The cake used is a hydraulic pressed cake made in Bombay from coarsely ground steamed seed For this reason the cake possibly acts slowly The results are poor for a cake so rich in nitrogen, and compare unfavourably with the other oil cakes, which, however, were all made in the country *ghani* and, therefore, probably acted more quickly Planted 30th March 1895, harvested 1st to 23rd March 1896 Irrigated 27 times
		1896-97 Ratoon cane	3·0	500	158 15	68,050		7,690	11·3	The crop looked fairly promising during the whole period of growth, but the outturn of Gul is rather disappointing It may clearly be inferred that hydraulic pressed cake made from coarsely ground steamed seed is slow in action even though rich in nitrogen Harvested 18th and 19th January 1897. Irrigated 16 times

Comparative Manures, Series B, 1895-96 and 1896-97.

Plot Number.	Manure.	Year of Crop	Manure per Acre	Nitrogen per Acre	Cost of Manure per Acre	Weight of Cane stripped and topped per Acre	Weight of Tops per Acre.	Weight of Gul per Acre.	Percentage of Gul to Cane	Remarks
			lbs.							
4	Bone meal	1895-96 New cane.	3,520	130	116					[illegible] that such is the case The action of bones is so slow that they cannot be *economically* used as manure for sugarcane The crop had the appearance of being starved throughout its growth Planted 1st April 1895; reaped 25th to 27th March 1896. Irrigated 27 times.
		1896-97 Ratoon cane.	3,343	130	122 11	30,900	—	3,705	11·9	The results this year with ratoon confirm the above Reaped 14th January 1897. Irrigated 16 times.

SACCHARUM: Sugar.

MANURING EXPERIMENTS.

Cultivation of Sugarcane in the

Plot Number	Manure.	Year of Crop.	Manure per Acre.	Nitrogen per Acre	Cost of Manure per Acre.	Weight of Cane stripped and topped per Acre.	Weight of Tops per Acre.	Weight of Gul per Acre.	Percentage of Gul to Cane.	Remarks.
			lbs.	lbs	Rs a.	lbs	lbs.	lbs.		
5	Dissolved bones.	1895-96 New cane.	3,520 Bones dissolved in acid	130	106 0	36,273	[illegible]	[illegible]	[illegible]	[illegible] times.
		1896-07. Ratoon cane.	4,404 dissolved bones or 3,343 crushed bones dissolved in acid.	130	207 5	55,845	..	6,365	11·6	Better results but not good enough to pay considering the expensive dressing of manure. Reaped 13th and 14th January 1897 Irrigated 16 times
10	Bone meal and crude nitre.	1895-96. New cane.	3,520 bone meal, 1,290 nitre.	250	204 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] Irrigated [illegible] times
		1896-97. Ratoon cane.	3,343 bone meal 1,230 nitre	250	255 0	50,38[illegible]		4,900	9 7	Nitre applied in 5 top dressings at intervals as above. The cane only yielded 53 7 per cent juice, whereas the average of all other manure plots was approximately 68 per cent. The percentage of Gul to cane is very low. I can offer no satisfactory explanation. Again, the cost of the manure about equals the value of the crop. Reaped 9th and 10th January 1897. Irrigated 15 times.
11	Dissolved bones and crude nitre.	1895 96 New cane.	3,520 bone meal dissolved and 1,290 nitre.	250	344 0	63,715	11,695	8,435	12·8	Nitre applied as in Plot 17 for similar reasons *It is clear that* dissolving the bones makes the manure more effective, but the cost is entirely prohibitive. Crop planted 31st March 1895, reaped 29th to 31st March 1896. Irrigated 27 times
		1896-97 Ratoon cane.	3,343 bone meal dissolved or 4,404 dissolved bones and 1,230 nitre	250	344 6	62,90[illegible]	...	7,845	12·[illegible]	Nitre applied as above Crop reaped 8th and 9th January 1897. Irrigated 15 times

64. The estimated cost per acre of cultivating sugarcane by hired labour in the Poona District is as follows:—

Chemistry of Sugarcane. Cost of cultivation.

	Rs.	a.
[illegible]	10	0
[illegible]	12	0
[illegible]	3	0
[illegible]	180	0
[illegible] per day ...	2	8
Making water compartments; contract-rate ...	2	4
Value of sets, 18,000 per acre ...	50	0
[illegible]	5	0
[illegible]	18	0
[illegible] at [illegible] intervals as required until June ...	12	0
Digging and making new beds in July ...	10	0
Water-rate (canal water) ...	40	0
[illegible]	2	0
[illegible]	16	0
[illegible]	85	0
[illegible] per acre ...	39	0
	486	12
Value of crop, 40 *Pallas* at Rs. 14 per *Palla* (price varies in any season from Rs. 12 to 18) ...	560	0

65. In growing a ratoon crop the cost of preparatory tillage is trifling. No sets are required; less manure is required than for new cane. [illegible] the saving [illegible] to Rs. 150 [illegible] ch *Gul* per acre as a fairly good crop of new cane. In paragraph 13, I have shown the actual cost of cultivation in an experimental plot at Mánjri at Rs. 325 per acre and value of produce at Rs. 447.

[illegible] the sugarcane [illegible] *Ledger* (*Medi-* [illegible] is a succinct [illegible] 128 of Dr. Leather's Final Report:—

Conf. Agricultural Ledgers Nos. 13 of 1895, 19 of 1896, and 3 of 1897.

"114. The investigations may now be conveniently referred to under the following heads:

(1) The composition of the juice—(*a*) in cane which had been transferred to long distances; (*b*) in cane which had been grown with varying amounts of manure; (*c*) in cane which had become *lodged*; (*d*) in the top ends of the cane; (*e*) in different varieties of cane.

(2) The relation between the amount of sugar in juice and its specific gravity.

(3) The determination of the amount of inversion which takes place during the concentration of the juice.

(4) The amount of sugar which becomes lost in the scum.

(5) The composition of the raw sugar, *gur*, *gul*, and *rāb*.

(6) The refining of sugar by means of the hand centrifugal separator.

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(7) The total amount of sugar in cane and the amount remaining in the crushed cane.

(8) The amount of phosphoric acid and nitrogen in the sugarcane crop.

"*A second example of this nature occurred in the case of the Poona Pundia, the variety* commonly grown around Poona This cane at Poona has been found to contain from 16 to 18 per cent of total sugar. It was sent to Cawnpore and Dumraon in 1895, but the crops at both farms produced a juice containing only 14 per cent of total sugar in the 1895-96 crop, and there was just about the same amount in the crop of 1896-97.

"Some further evidence was gained during the past season. A number of varieties,

"116. (1-*b*).—*The composition of the juice of cane which has been grown with varying*

uniform,

very acid cent- nely,

from 15 to 17 per cent. of cane sugar and 1·0 to 1·8 per cent. of glucose

"At Cawnpore a small cane, the *Matno*, was grown in 1894 95 and 1895 96, with different descriptions of manure, in varying amount (the nitrogen varied from *nothing* on the unmanured plot to nearly 200 lbs.

* This is confirmed by the remarkable manner in which the Southern Maratha varieties recovered to their normal standard in the second year of cultivation at the Poona Farm, although they had deteriorated considerably in the first year's cultivation. See description of Bombay varieties pages 43 to 57.—J. M.

Bombay Presidency. (*James Mollison.*)

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Cawnpore in 1893-97 another variety was grown, a thick *Pundia* called *Madrasi*, and this was manured with different materials containing from 250 to 500 lbs. nitrogen per acre, the amounts being in every case *large*. The percentage of cane-sugar varied from 14 to 15·5 per cent. and the glucose from 0·5 to 0·9 per cent.

"Thus the evidence adduced from three somewhat extensive series of tests pointed uniformly to the conclusion that neither the kind of manure, nor its amount, exercised any influence on the quality of the juice of sugarcane

"*Another piece of similar evidence was obtained in connection with the Dumraon experiments*, where it is probable that high manuring had, in the case of certain canes, reduced the proportion of sugar. But a consideration of the evidence on this subject clearly offers an explanation of the effects noticed

propagating from them.

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"Moreover, it so happens that in no part of India is the cultivation of cane, in most respects, more perfectly carried out than at Burdwan, and one at least of the varieties there [illegible]

[illegible] acid will be re[illegible].

[illegible]

"119. (1-e)—*The composition of the juice of different varieties of cane.*—The amount [illegible]

"The proportion of juice expressible will be dealt with under (7).

[illegible]

North-Western Provinces have much less sugar in their juice. Of the total sugar, the greater part is of course cane-sugar.

"The glucose has in most cases been determined in the juice also, and its proportion varies from a half up to two per cent.

[illegible]

"120. (2) [illegible]

"In the case of sugar being dissolved in pure water, its amount may be determined with very fair accuracy by observing the specific gravity of the solution, there being a very simple relation between the two.

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"Sugarcane juice is not, however, a solution of only sugar in water; other substances are present besides, which affect the density. It occurred to me, however, that the amount of these other substances might be fairly constant, and if so, the insertion of a uniform correction would enable one to calculate the percentage of total sugar from the specific gravity

"Accordingly I compared the specific gravity of a large number of samples of juice with the amount of sugar actually found by analyses The result of this was, that the difference between the percentage of sugar as shown by the hydrometer, and that actually present, proved to be fairly constant as I had expected This difference amounted to about 2 per cent. in the majority of cases, and I calculated out a set of tables by means of which any one can find out the per cent. of total sugar with the aid of a hydrometer Of course such a method is only approximate, but the result will not be more than half a per cent from the truth. Also it is to be observed, one only learns the amount of *total* sugar by this means, but since the amount of glucose is only small, the method will be found very useful for field work, when the more exact methods of the chemist are not available

"121. (3) *The amount of inversion which takes place when boiling down the juice.*—All cane juice contains organic acids, and these at a boiling heat possess the unfortunate property of converting a part of the crystallisable cane sugar into uncrystallisable glucose So far as the *food value* of the resulting sugar is concerned, the change is probably of no great consequence

[illegible]

believe I have more or less succeeded The addition of a small quantity of quicklime in water will neutralise the acidity of the juice, and thus prevent in a great measure the process of inversion Too much lime must not, however, be employed, otherwise the resulting sugar becomes black, and its market value decreased. Litmus paper was at first employed to detect when sufficient lime had been added, later I found that there is a natural colouring matter in the juice which could be equally well employed

[illegible]
of mol.
at Caw
simply
Messrs.

[illegible]

"This sugar, which is unavoidably taken in the scum is, however, not wasted At Poona the people recover part of it by putting the scum into water, boiling the liquid and again skimming off the scum At Cawnpore the scum is given to cattle as a food

[illegible]

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SACCHA-RUM: Sugar.

Cultivation of Sugarcane in the

ocks weighing from
ilst warm and soft
in other districts,
owed to solidify in
ing of recommenda-

"The composition and colour of this description of raw sugar will vary very considerably, much depending on both the quality of the juice and the mode of working.

on of glucose
ice be poured
arated, it is
During the
the product

"Finally, if the acidity of the juice be neutralised, the *gur* will contain a lower proportion of molasses (*vide* paragraph 121).

"Some samples of cultivators' *gur* from Oudh which I analysed, contained of cane-sugar from 63 to 72 per cent, glucose from 9 to 10 per cent, mineral matter from 3 to 4 per cent., water and other impurities from 15 to 24 per cent

no doubt that, given good cane and careful manufacture, the latter standard can be maintained

"This description of sugar is prepared specially for the purpose of refining. Frequently it is put into sacks which are then placed one on another in order to increase the

"One sample of sugar refined by this process contained 96·6 per cent of cane sugar and 0·89 per cent glucose.

"125. (6) *The hand centrifugal sugar separator.*—Another much better means of
Bur-
rked
utes
, 20
next
by
to

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"The proportion of clean crystallised sugar (what is called *brown sugar* in England) which is obtained, will of course vary somewhat with the nature of the *rab* operated upon. In one of Messrs. Thomson and Mylne's experiments a yield of 40 per cent. was obtained, in another 52 per cent. In two experiments which I made 48·6 and 51·9 per cent. was obtained.

"The amount of *gur* obtained after boiling down the molasses seems to vary between 25 and 40 per 100 of *rab* operated upon.

"The so-called 'turbine' or 'centrifugal' sugar is very fairly pure. I have analysed several samples, from which it appears that it contains from 90 to 95 per cent of cane-sugar, from ⅔ to 2 per cent. of glucose, from ½ to 3 per cent. of moisture, from ⅔ to 1½ per cent. of mineral matter and from 2 to 3 per cent. of other (organic) impurities.

"The *gur* obtained by boiling down the molasses is quite as good as much of the *gur*

"In addition to a regular trade which has sprung up in the Shahabad District in 'centrifugal' sugar, which is exported long distances by rail, a similar trade has arisen in the *gur* made from the molasses. I believe that a great future exists for this hand centrifugal machine, for it is clear that a very material economy in sugar must take place by its means over the native processes in which the greater part of the molasses becomes unfit for human consumption, and thus actually lost entirely so far as food-supply is concerned.

"126. (7) *The total amount of sugar in sugarcane and the amount remaining in the crushed refuse.*—Since it is obvious that by no process of simple crushing, all the juice can be expressed from cane, it becomes an interesting question, how much is left with the refuse?

"The matter is of far greater importance than might at first sight appear. It has generally been assumed in India that everything related to the crushing process depends entirely on the mill, and the question of difference in the variety of cane has rarely, if ever, been considered.

the mills at Cawnpore having been of the very best workmanship and pattern.

"The difference between 50 and 70 per cent. of juice is so great, that I decided to

the refuse)

"The methods employed are sufficiently clearly set forth in paragraphs 11 to 13 of *Agricultural Ledger No. 19 of 1896.*

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"If, however, another item in the composition of cane, namely the *fibre*, be brought into the comparison, and its effect be considered, the cause of these variations in the amount of juice expressed becomes evident.

"[illegible] that so soon as cane is crushed up by the mill and the [illegible] the juice from running out is that [illegible] spongy material, and just as *it is* [illegible] likewise is it impossible to express all the juice out of cane.

this investigation, [illegible] the fresh cane will hold twice to two and a half times its own weight of juice [illegible] only the surplus to run out

"Thus, even assuming that the juice of [illegible] that of the thick ones (and it is probable th[illegible] varieties in place of thin ones, would mean a [illegible] 30 per cent. over that at present obtained, and this without any [illegible] manure, water, &c.

"127 (8) *The amount of phosphoric acid and nitrogen in the sugarcane crop* — [illegible] this crop, and it has

[illegible] The cane, [illegible] weighed, and portions of each submitted to analyses [illegible] at in crops [illegible] 50,000 lbs. there was generally contained some 50 to 60 lbs. of [illegible]

DESCRIPTION OF SUGARCANE.

"128. *Concluding remarks*—As to the general importance of experiments on the ... It is clear in the first place ... about 75,000 tons annually), ... at, whilst an article of diet, ... of production is higher than ... sugar produced goes to the ... here is the difference between ... the one hand, where, with ... ons of raw sugar is obtained, ... here the outturn is certainly ...

"As has been shown in the course of this section of my report, there is no need to go outside of India for good varieties, nor to other countries for good methods of cultivation. The best of varieties are met with, and the methods of cultivation in some parts are very perfect What is wanted is the introduction of these good varieties and good methods into those parts, particularly the North-Western Provinces and Behar, which Provinces, it must be recollected, include much the largest area under cane of any Provinces of India."

DESCRIPTION OF VARIETIES OF SUGARCANE.

By Dr Leather and Mr. Mollison.

The following notes contain a description of a number of varieties of sugarcane which have been examined. It is possible that some of these are cultivated in other parts of India, doubtless also there are many other varieties which still remain to be described, and the writers think that the following introductory remarks will be of assistance to other agriculturists not only in the recognition of varieties included in these notes and growing elsewhere, but that they will admit of descriptions of other varieties being reduced to a common standard. It must be stated, however, at the outset, that, although among varieties ... colours (to be pres... case of any one ... appearances vary. For example, if a number of canes of the *Madrási Pounda* of the North-Western Provinces or the *Pundia* of Poona or the *Samsára* of Burdwan be examined, it can be at once seen that the colour varies in any of these varieties from green to straw yellow, but the colour may be modified so that some canes may be almost entirely green whilst in others some portions may be entirely yellow or the yellow may have an orange t... ...arly noticeable on canes growing on ... fully exposed to the sun. In the ... llow colour is sometimes the general colour of the whole cane. The same variety may vary in shape between the nodes; a cane may be generally of, say ...

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2. Correspondingly great variations will be found among varieties in respect of other particulars, such as the extent to which aerial roots develope, the colour and shape of the rings at the nodes &c.

At the same time each variety *is* distinct, and when canes of two varieties are placed together, the differences become much more apparent than if they are separately examined.

Occasionally no differences can be detected between the striped canes of two varieties. For example, the *Mungo* and *Bhurli* canes of Behar are so much alike that they are indistinguishable when stripped of the leaves; the leaves of the two are, however, quite distinct, those of the *Mungo* being of a paler green and inclined to crumple up, whilst those of the *Bhurli* variety are darker in colour and remain flatter. Such a case is, however, in the experience of the writers, exceptional, and varieties as a rule are sufficiently distinct to enable one to recognize them without the leaves. In fact the leaves are commonly of but little assistance in determining the variety.

3. In the following paragraphs the points which have been more particularly examined are dealt with in detail.

4. *Colour*—Sugarcane may be of the following colours:—

(1) Pale yellow or drab.
(2) Pale yellow and green.
(3) Nearly entirely green.
(4) Purple or purple red.
(5) Purple and yellowish green in stripes.
(6) A more or less intimate mixture of dull purple and dull green best described as a dirty colour.

Of these, however, only (4), (5) and (6) are really so distinct that the cane can be definitely said to belong to the one or the other. A striped cane for instance is always striped purple with yellow or yellow-green. A cane that might be classed as wholly purple, when minutely examined, may or may not have longitudinal stripes of a darker or lighter colour, these being most distinctly marked on the upper internodes and only faintly marked on the lower. In purple canes the depth of colour may vary from very dark purple to a light reddish purple. It is at times practically impossible to decide whether a particular cane should be classed as pale yellow or drab, or pale yellow and green, and again it is hard to differentiate between pale yellow and green and nearly entirely green. It has been found that some varieties are almost or quite destitute of green in a certain field, *e.g.*, *Betta Kabbu* at Belgaum and *Dhaur* and *Rakra* in the North-Western Provinces; but tinges of green are frequently found on the same variety when cultivated under other conditions, *e.g.*, *Betta Kabbu*, which at Poona had tinges of green on it. The same may be said of canes being

DESCRIPTION OF SUGARCANE.

all green. Sometimes a variety will be quite destitute of yellow in a certain field, but the same variety will be found in another field or locality to be quite yellow in places. For example the *Mungo* at Rosa was entirely green, whilst at Bára Banki it was partly yellow. The simplest plan is therefore to class all canes of a yellow or yellowish-green or green colour together and state the colour as found in a particular variety when examined.

Canes might then be divided into four classes as regards colour; namely—

(1) Yellow or green or both.

(2) Purple.

(3) Purple and yellowish green in stripes.

(4) Purple and green mixed to form a dirty colour.

It not infrequently happens that a yellow green cane will have very distinct patches of red or pink upon it. Such for example is the *Ramrie* of Sitápur District, North-Western Provinces. But this is quite distinct from the purple colour of canes belonging to classes 2 and 3.

5. *Other points of colour.*—In reference to the colour of canes several other points are deserving of notice.

Very frequently patches or smudges of dirty black are found adhering to a cane. This is quite external and may readily be rubbed off. It cannot be said
on some varieties,
origin of the smu
or red appear on
leaf still adheres. This colour is not always on every cane of one variety in the same field but is apparently a *common* characteristic on some varieties. For instance the *Ramwie* cane of the North-Western Provinces was tinged with pink at Sitápur (Oudh) and in one of the fields examined at Bára Banki (Oudh), but in another field of this variety at Bára Banki this colour was almost entirely absent.

Bloom.

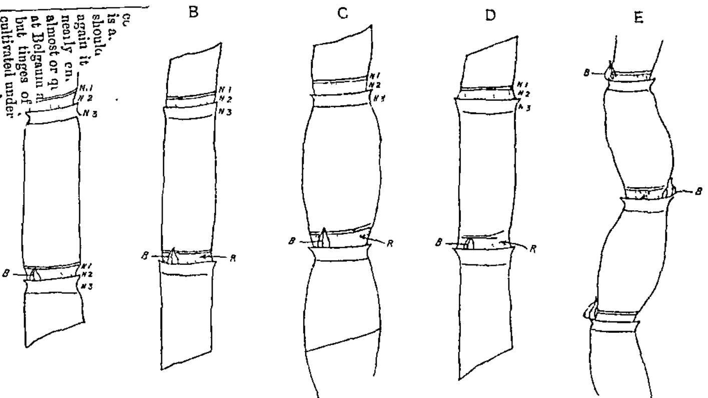
6. *Bloom.*—There is on some varieties a of waxy bloom which covers the cane more or less, and ce or absence of this bloom, as also the degree to wh ane seems to be quite characteristic of varieties.

General shape.

7. *General shape of Ca* ry characteristic shapes, some of the princip he accompanying diagram and shown as A, B e first three are perhaps the most comm

A—represents on the nodes, but is otherwise a cane o

.M SHOWI   DIFFERENT TYPES OF CANE



cc
is a.
shoulc
again it
nearly en.
almost or q
at Belgaum a
but tinges of
cultivated under
had tinges of grc

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GANGADHAR MOODLIAR

DESCRIPTION OF SUGARCANE.

(if not over ripe) they are uniformly rounded or oval, whilst in the case of others they are more pointed. In some varieties the scale-like covering which protects the buds is coarse and fibrous in texture, in others it is smooth, thin and shining

Root dots.

11. *Root Dots.*—Regarding the little dots, indicating the seat of the growing point of the future root, not much need be said. They are distinct on some varieties but only just perceptible on others.

Aerial roots.

12. *Aerial Roots.*—Sugarcanes have a general tendency to throw out aerial roots *from the nodes which are near the ground*, but some varieties produce them not only close to the ground, but for some distance up the cane. Occasionally this is a very pronounced characteristic. For example the *Sháhájanpuri* and the *Madrási* or *Madrási Pounda* of the North-Western Provinces and the *Samsára* of Bengal frequently produces them over its entire length and moreover the aerial roots of one node grow towards and join those of the next node.

Girth.

[illegible] not only between [illegible] of the variety. [illegible] thin specimen of [illegible] good specimen of that variety. For this reason the girth of a cane is a most important consideration If an unknown variety has a general thickness of 2″ but is similar in other points to one having a general girth of 4″, it may be said with certainty that they are different varieties. The girth of some varieties is almost uniform throughout the entire length. On the other hand sometimes canes are thinner at the top end than the bottom and less frequently they are thinner at both ends than at the middle.

Length between nodes.

14. [illegible] of a cane [illegible] all varie- [illegible]

The *Hallu Kabbu* of Belgaum, for example, has generally long internodes, whilst the *Betta Kabbu* of Belgaum has frequently short ones. [illegible] nodes. The *Meva* [illegible] If a crop of [illegible] manure or any [illegible]

[illegible]

measure the one into the other.

In the case of colour, any cane may be easily placed under one of the four groups which have been suggested, but in the case of the colour and distinctness of the bands at the nodes, whether the ring (marked N_1 in the diagram) is distinct or not, whether a cane is enlarged or

VARIETIES OF CANE EXAMINED

DR. LEATHER's *Analysis*—

	Poona Farm Crop 1896. (Fresh imports)	1897. (Acclimatized 1 year)
Percentage of juice to cane ...	59·15	67·25
Do. of sugar to juice ...	10·98	14·80
Do. of glucose in juice ...	1·40	1·00

MALABÁRI.

Variety—**Malaba'ri.**

Where grown—Surat District.

General Appearance—A fairly thick, tall, soft cane; yellow-green colour; cane generally somewhat bent at top end; does not ratoon well.

Type—C; internodes fairly bulged.

Bloom—Very little.

Nodes—Ring N_1—Indistinct on lower nodes; fairly well marked on upper nodes, pale yellow and green.

Band N_2—Yellow and green, root dots well marked.

Band N_3—Light blue-gray colour.

Height—7½ to 9 feet, without tops, when well grown.

Girth—4" to 4¾".

Internodes—3½" to 5½".

Aerial Roots—On 3 or 4 lower nodes only.

Buds—Very small, covered with fibrous dull-brown covering.

VÁNSI OR BAMBOO; BETTA KABBU.

Variety—**Va'nsi** or **Bamboo**, same as **Betta Kabbu** of Southern Marátha Country.

Where grown—Surat District; Belgaum.

General Appearance—A cream coloured or light yellow cane; vertically scored with black or brown lines; very tall; thin and hard; of uniform thickness throughout; the leaves are narrow and long and the dried dead leaves enclose the cane, and thus protect it from damage by jackals and pigs.

Type—B.

Bloom—Good deal; black patches numerous.

Nodes—Ring N_1—Distinct dull yellow colour.

Band N_2—Regular in width; cream colour; root dots not numerous, and not distinctly marked.

Band N_3—Not well marked; light-grey colour; sometimes nearly white.

Height—Without tops 8 feet; some canes 10 feet long, when well grown.

Girth—2¼″ to 2¾″.

Internodes—3½″ to 5″.

Aerial Roots—On 4 to 6 lower nodes.

Buds—Rounded small not prominent, shining light green scale covering on upper, and brown or *khaki* scales on lower buds.

VARIETIES OF CANE EXAMINED

DR. LEATHER'S *Analysis*—

	Belgaum Crop, (Batti Kaldin) 1896 (Local)	Poona Farm Crop, (Bamboo or Vansi) 1896. (Fresh imports)	1897 (Acclimatized 1 year)
Percentage of juice to cane ...	60·00	57·70	59·00
Do. of sugar to juice	12·61	9·53	11·50
Do. of glucose in juice.	0·95	1·54	1·00

BHURI

Variety—**Bhuri**

Where grown—Surat District

General Appearance—A fairly tall, moderately thick, hard cane, the colour varies between the lower and upper internodes considerably; the lower ones are a dirty-looking admixture of brown, dull purple, and dull green; the upper nodes are dull purple mixed with a good deal of dull green, the canes are mostly scored or blotched with gray.

Type—E, only slightly zig-zag in shape

Nodes—Ring N_1—Not very distinctly marked

Band N_2—Distinctly marked but varies with the cane in colour between upper and lower nodes, root dots very prominent

Band N_3—Hardly observable in lower nodes; a ring of grey bloom on upper nodes.

Height—Without tops 6 to 7 feet when well grown.

Girth—3½″ to 3¾″.

Internodes—3½″ to 4½″.

Buds—Fairly large; flattened; pointed; covered with fibrous *khaki* coloured scales.

Aerial Roots—On lower nodes.

PHOJBHURI.

Variety—**Phojbhuri.**

Where grown—Surat District.

General Appearance—Very like *Bhuri* in appearance, excepting that the colour is yellow green on upper internodes, but irregularly tinged here and there, with brown and purple on lower internodes.

SACCHARUM: Sugar.

Cultivation of Sugarcane in the

VARIETIES OF CANE EXAMINED.

Type—E; only slightly zig-zag in shape.

Bloom—A little.

Nodes—Ring N_1—Faintly marked.

Band N_2—Irregular in width; yellow or green in colour; root dots fairly distinctly marked.

Band N_3—Faintly marked on lower nodes, but more distinctly on upper; blue-gray colour.

Height—6 to 7 feet when well grown.

Girth—3½" to 4".

Internodes—3½" to 4½".

Buds—Medium size; flat; pointed; covered with *khâki* coloured scales.

Aerial Roots- On lower nodes.

SONGADI.

Variety—**Songadi**

Where grown—Surat District.

General Appearance—A dull purple mixed with dull green, scored irregularly with *khâki* coloured marks; this cane is tall, hard, and nearly of uniform thickness throughout the whole length

Type—E.

Bloom—None.

Nodes—Ring N_1—Very wide and irregular in shape; varies in colour, generally purple.

Band N_2—Irregular in shape, and colour; root dots distinct, and lighter in colour; thin band.

Band N_3 - Regular in shape, but varies in colour throughout the length of the cane in a very erratic manner.

Height—8 to 10 feet without tops, when well grown.

Girth—3½" to 4".

Internodes—5" to 6".

Aerial Roots—On lower nodes only.

Buds—Fairly large, flat, pointed, and *khâki* coloured.

[KALI] JÁDI.

Variety—**Ka'li Ja'di.**

Where grown—Surat District.

General Appearance—A tall, hard cane of almost uniform thickness from root to top; dull purple in colour; scored and blotched with *khâki* colour.

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VARIETIES OF CANE EXAMINED.

Type—E; but internodes only slightly zig-zag.

Bloom—A little.

Nodes—Ring N_1—Indistinct on lower nodes, distinct and yellow-green colour on upper nodes.

Band N_2—*Purple with faintly marked root dots on lower* nodes, pale green on upper nodes.

Band N_3—Distinct band of blue-grey bloom.

Height—6 to 7 feet, when well grown.

Girth—3½″ to 4″.

Internodes—4″ to 4½″.

Aerial Roots—Very few.

Buds—Small, flat, blunt, and *khâki* coloured.

DEOGADI.

Variety—**Deogadi.**

Where grown—Ratnágiri District.

General Appearance—A very tall, straight, fairly thick cane; moderately hard; smooth; yellow and pale green in colour.

Type—A, internodes very slightly bulged.

Bloom—Very slight.

Nodes—Ring N_1—Distinctly marked; very regular in width; narrow; varies in colour, mostly deep yellow.

Band N_2—*Very regular; distinctly marked, green-yellow in colour, root dots numerous and very distinct.*

Band N_3—Grey-blue in colour and very distinct.

Height—7 to 8 feet without tops; very well grown canes over 10 feet without tops.

Girth—3½″ to 4½″; middle internodes slightly thicker than lower and upper ones.

Internodes—3½″ to 5½″.

Aerial Roots—None.

Buds—Small, rounded, fairly sharp points; covered with a shining scale covering; varies in colour.

DR. LEATHER'S *Analysis*—

		Poona Farm Crop. 1896. (Fresh imports.)	Poona Farm Crop. 1897. (Acclimatized 1 year.)
Percentage of juice to cane	...	70·50	68·0
Do. of sugar to juice	...	11·46	14·3
Do. of glucose in juice	...	1·87	0·3

VARIETIES OF CANE EXAMINED.

MÁHIM YELLOW GREEN; PUNDIA.

Variety—**Máhim Yellow Green**; same as Poona **Pundia** an[d] **Pundia** of Belgaum, &c.

Where grown—Máhim, Thána District.

General Appearance—A thick, soft, tall cane tapering to small inter[-]nodes at the top; yellow green in colour; cane generally bent, o[r] crooked.

Type—C; internodes bulged considerably, especially at the top end cane much inclined to crack vertically before ripening like all sof[t] thick varieties; ratoons well.

Bloom—Good deal.

Nodes—Ring N_1—Irregular, not particularly noticeable; orange.

Band N_2—Wide and irregular in shape; yellow or yellowish green; root dots numerous and easily seen.

Band N_3—Wide; distinct; blue grey in colour.

Height—7½ to 9 feet without tops; some canes 10 feet long.

Girth—4½" to 5".

Internodes—3½" to 5".

Aerial Roots—Few or none.

Buds—Rounded, prominent, moderate in size; covered with dull brown or *khâki* fibrous covering.

DR. LEATHER'S *Analysis*—

	Poona Farm Crop. (Máhim Yellow Green.) 1896. (Fresh imports.)	Poona Farm Crop. (Máhim Yellow Green.) 1897. (Acclimatized 1 year.)	Poona Farm Crop. (Pundia) 1896. (Local)	Belgaum Crop. (Pundia) 1896. (Local.)
Percentage of juice to cane ...	71·00	70·58	68 to 73	63 to 73
Do. of sugar to juice ...	12·38	14·80	16 to 17·4	13 71 to 17·49
Do. of glucose in juice ...	1·87	0 80	1·2 to 1·6	0 83 to 1·57

GREEN MAURITIUS.

Variety—**Green Mauritius.**

Where grown—Imported in 1893 by the Bombay Agricultural Department.

General Appearance—A tall, moderately thick, fairly hard cane, lower [illegible] colour changes gradually towards the top to a [illegible] ned to [illegible] well.

Type—A.

Bloom—None.

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VARIETIES OF CANE EXAMINED.

Nodes—Ring N_1—Well marked, rather wide; much the same colour as the cane.

Band N_2—Mostly pale yellow tinged with green, regular in width; root dots fairly well marked.

Band N_3—Distinct; light blue grey in colour.

Height—7 to 7½ feet without tops.

Girth—3½" to 4".

Internodes—3½" to 4½".

Aerial Roots—Few or none.

Buds—Round; fairly prominent; slightly pointed; covered by a light *khâki* fibrous covering.

DR. LEATHER'S *Analysis*—

	Poona Farm Crop. 1896.	Poona Farm Crop. 1897.
Percentage of juice to cane ...	65·70	68·75
Do. of sugar to juice ...	14·71	14·10
Do. of glucose in juice ...	0·99	1·40

RASDÁLI; RASVÁLI; RASÁLI.

Variety—**Rasda'li; Rasva'li; Rasa'li**; that is, juicy.

Where grown—Haliál, Kánara District.

General Appearance—A tall, fairly hard, yellow green cane of moderate thickness.

Type—A.

Bloom—Little or none.

Nodes—Ring N_1—Distinct; narrow; varies in colour; mostly green or yellow.

Band N_2—Wide; fairly regular in width; root dots numerous and distinct.

Band N_3—Wide; distinct; blue grey in colour.

Height—7 to 7½ feet without tops, when well grown.

Girth—3¼" to 3¾".

Internodes—5" to 6".

Buds—Small; prominent; rounded; covered by brown or *khâki* scales.

DR. LEATHER'S *Analysis*—

	Poona Farm Crop. 1896. (Fresh imports.)	Poona Farm Crop. 1897 (Acclimatised 1 year.)
Percentage of juice to cane ...	60·40	62·11
Do. of sugar to juice ...	13·18	15·30
Do. of glucose in juice ...	1·49	1·00

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VARIETIES OF CANE EXAMINED.

YELLOW GREEN.

Variety—**Yellow Green.**

Where grown—Bijápur; Bágalkot.

General Appearance—A yellow green cane; fair in length and thickness; slightly scored with brown; lower internodes not so thick as those in middle of cane.

Type—A; sometimes C; internodes very slightly bulged.

Bloom—A little.

Nodes—Ring N_1—Distinctly marked in upper nodes but not so distinct on the lower ones; varies in colour, but commonly part of ring, bright brown.

Band N_2—Distinctly marked; pale green and yellow in colour; root dots very distinctly marked.

Band N_3—Very distinct and regular; of blue grey colour.

Height—8 to $8\frac{1}{2}$ feet without tops, when well grown.

Girth—4″ to $4\frac{1}{2}$″.

Internodes—Very regular in length $4\frac{1}{2}$″ to 5″.

Aerial Roots—None.

Buds—Small, rounded; pointed, covered with *khâki* coloured scales.

DR. LEATHER'S *Analysis*—

	Poona Farm Crop. (Bijápur Yellow Green.) 1896. (Fresh imports).	1897. (Acclimatized 1 year.)	(Bágalkot Yellow Green.) 1896. (Fresh imports.)	1897. (Acclimatized 1 year)
Percentage of juice to cane ...	70·40	70·62	68·10	68·75
Do. of sugar to juice .	14·30	16·60	12·34	16·20
Do. of glucose in juice .	1·57	1·10	1·94	1·40

HULLU KABBU.

Variety—**Hullu Kabbu** (*Hullu* = grass and *Kabbu* = sugarcane.)

Where grown—Southern Marátha Country.

C[illegible] yellow green in [illegible] y patches; cane [illegible] ratoons well.

Type—Generally B.

Bloom—Good deal.

Nodes—Ring N_1—Orange yellow, tinged with green on upper nodes.

Band N_2—Dull yellow; root dots distinct.

Band N —Grey.

Bombay Presidency. (*James Mollison.*)

SACCHARUM: Sugar.

VARIETIES OF CANE EXAMINED.

Height—7 to 8 feet: some canes 10 feet without tops, when well grown.

Girth—1¾" to 2".

Internodes—5" to 7".

Aerial Roots—A few on lower nodes only.

Buds—Slightly prominent; elliptical; lower buds covered by brown scales; upper ones light green in colour.

DR. LEATHER's *Analysis*—

	Poona Farm Crop 1896. (Fresh imports)	Poona Farm Crop 1897. (Acclimatized 1 year.)	Belgaum Crop. 1896. (Local.)
Percentage of juice to cane ...	52 60	56 17	55 90 to 59 80
Do. of sugar to juice ...	16·06	16 90	14 27 to 14 92
Do. of glucose in juice ...	A trace only.	0 70	A trace to 0·74

Variety—**Yellow Green.**

YELLOW GREEN.

Where grown—Ránebennur, Dhárwár District; and Chikodi, Belgaum District.

General Appearance—A light green or yellow cane; moderately thick; fairly tall and soft.

Type—A; sometimes C; internodes slightly bulged; nodes not prominent.

Bloom—Some.

Nodes—Ring N_1—Distinctly marked; narrow; dull orange brown in colour, which, however, varies in lower nodes.

Band N_2—Distinctly marked; wide; root dots distinct and numerous.

Band N_3—Distinct; wide; dull grey in colour.

Height—6½ to 7 feet without tops, when well grown.

Girth—3" to 4".

Internodes—3" to 5".

Aerial Roots—None.

Buds—Small; round or oval; blunt; covered by dull *khâki* scale-like covering, which gets fibrous on lower buds.

DR. LEATHER's *Analysis*—

	Poona Farm Crop. (Chikodi Yellow Green) 1896. (Fresh imports.)	Poona Farm Crop. (Chikodi Yellow Green) 1897. (Acclimatized 1 year.)	(Ránebennur Cane.) 1896. (Fresh imports.)
Percentage of juice to cane ...	65 50	68 47	64·10
Do. of sugar to juice ...	11·35	11·90	12·04
Do. of glucose in juice...	1 80	1·90	1·48

SACCHARUM: Sugar.

Cultivation of Sugarcane in the

VARIETIES OF CANE EXAMINED.

DR. LEATHER'S *Analysis*—

	Poona Farm Crop.			
	(Bijápur Purple Cane.)		(Bassein Purple Cane).	
	1896.	1897	1896.	1897.
	(Fresh imports.)	(Acclimatized 1 year)	(Fresh imports)	(Acclimatized 1 year)
Percentage of juice to cane ...	63·00	62·50	57·10	61·80
Do. of sugar to juice ...	13·27	13·80	13·31	13·60
Do. of glucose in juice ...	1·33	1·00	1·22	1·70

KARE KABBU.

Variety—**Kare Kabbu** (*Kare*=black, *Kabbu*=sugarcane.)

Where grown—Belgaum, Khánápur, Belgaum District; and Ránebennur, Dhárwár District.

Ge[illegible]

Type—E, but only slightly zig-zag.

Bloom—None.

Nodes—Ring N_1—Distinct; varies in colour similarly to Band N_2.

Band N_2—Light purple or yellow green at upper end of cane; purple at lower end; root dots distinct.

Band N_3—Blue grey.

Height—6 to 7½ feet without tops, when well grown

Girth—3¼" to 3¾".

Internodes—3" to 4".

Buds—Dull *khákí* or light brown in colour; medium in size; oval.

DR. LEATHER'S *Analysis*—

	Poona Farm Crop.			Belgaum, Khánápur and Ránebennur Crop.
	(Belgaum Cane)	(Khánápur Cane.)	(Ránebennur Cane.)	(Local.)
	1896.	1896.	1896.	1896.
Percentage of juice to cane ...	60·70	63·00	54·10	60·70 to 66·00
Do. of sugar to juice ...	11·67	6·13	10·27	13·32 to 16·67
Do. of glucose in juice ...	1·54	2·57	1·60	0·85 to 1·17

RÁMRASDÁLI.

Variety.—**Rámrasdáli.**

Where grown—Haliál, Kánara District.

General Appearance—A fairly tall soft cane; uniform in thickness; irregularly streaked with dull purple and pale green streaks, varying very irregularly in width; ratoons fairly well.

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Bombay Presidency. (*James Mollison*)	SACCHARUM: Sugar.

VARIETIES OF CANE EXAMINED

Type—A and E combined; only slightly zigzag; internodes slightly bulged sometimes.

Bloom—A little.

Nodes.—Ring N_1—Fairly distinct; varies in colour.

Band N_2—Regular in shape; not distinctly marked; root dots fairly distinct.

Band N_3—Distinct, light blue-gray in colour.

Height—7 to 8 feet without tops.

Girth—3¼" to 4"; regular throughout.

Internodes—5" to 7".

Aerial Roots—None or few.

Buds—Fair sized; rounded, pointed; covered by fibrous brown [illegible].

DR. LEATHER'S *Analysis* —

	From Fresh Cane, 1896. (Fresh imports.)	1901. ([illegible] 1 year)
Percentage of juice to cane	70·19	67·1
Do. of sugar to juice ..	[illegible]	[illegible]
Do. of glucose in juice .. .	2·4	[illegible]

Variety—Streaked Cane.

[illegible]

Where grown—Gadag, Dhárwár District; also [illegible], Belgaum District.

General Appearance—A tall, thick, soft cane; irregularly streaked in purple and green or pale purple and yellow [illegible] distinct as in *Rámrasdáli*.

Type.—C and E combined, but internodes only slightly bulged and cane only slightly zig-zag in appearance.

Bloom—Good deal.

Nodes—Ring N_1—Fairly well marked; varying [illegible] yellow; lower nodes irregular in [illegible].

Band N_2—Irregular; also varies in [illegible] distinct but small.

Band N_3—Distinct; light blue-gray [illegible].

Height—7 to 8 feet without tops.

Girth—4" to 4½"; thick canes 5".

Internodes—4" to 5"; lower internodes slightly [illegible] than the middle ones.

Aerial Roots—None.

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VARIETIES OF CANE EXAMINED.

Buds—Fairly large; pointed; prominent; covered with *khaki* coloured scales.

DR. LEATHER'S *Analysis*—

	Poona Farm Crop (Streaked Cane from Gadag.) 1896. (Fresh imports.)	1897. (Acclimatized 1 year)	Belgaum, Khánápur, and Gadag Crop (Local) 1896.
Percentage of juice to cane ...	70·20	69·86	71
Do. of sugar to juice ...	8·87	11·50	14·55 to 17·37
Do. of glucose in juice ...	2·12	0·50	0·79 to 1·39

(B)—VARIETIES OUTSIDE THE BOMBAY PRESIDENCY.
(*Examined by* DR. LEATHER.)

MADRÁSI POUNDA.

Variety—**Madra'si Pounda.**

Where grown—Sitápur; Bára Banki. Bareilly.

General Appearance—A thick, orange, yellow to green straight cane; this is a very erect strong cane, harder outside than most *Poundas*; little liable to crack lengthwise or to fall down, it gives about 70 per cent. of juice and has about 15 to 16 per cent. of sugar in the juice (*vide* Cawnpore Farm Experiments).

Type—A; frequently C.

Bloom—None.

Nodes—Ring N_1 —Generally indistinct or absent.
Band N_2 —Drab or green; root dots prominent.
Band N_3 —Distinct; gray coloured.

Height—5 to 8 feet.

Girth—4″ to 4¾″.

Internodes—3½″ to 5″.

Aerial Roots—Common; they grow from one node to the other like the Sháháranpuri *Pounda*.

Dry Leaves—Generally open out.

Variety—**Samsa'ra.**

Where grown—Dumraon; Burdwán.

General Appearance—A yellow green cane; frequently lemon-yellow, or orange coloured where exposed to sunlight; erect.

Type—C; sometimes A.

Bloom—Very little; no scorings.

Nodes—Ring N_1 —Narrow; indistinct.
Band N_2 —Orange or yellow green; root dots distinct.
Band N_3 —Well defined; gray.

VARIETIES OF CANE EXAMINED.

Height—4 to 6 feet at Damnaon; 8' to 12' feet at Burdwan.

Girth—$3\frac{1}{2}''$ to 4''

Internodes—$3\frac{1}{2}''$ to $1\frac{1}{2}''$.

Aerial Roots—Many, they grow from one node to the next below in a very characteristic manner.

Buds—Large, groove narrow deep.

Dry Leaves—Open out from cane.

DR. LEATHER'S *Analysis*—

	Damraon Castor cake plot	Farm Crop Cattle-dung plot.	Burdwan Castor cake plot.	Farm Crop Cattle-dung plot	Village Kantalgachi.	Village Bamjatia.	Village Hartsimal.
Percentage of juice to cane . ..	...	...	...	...	71 80	73 20	67 70
Percentage of sugar to juice	12 35	15 36	14 24	14 24	15 21	15 21	15·24
Percentage of glucose in juice ..	1·34	0 72	1 86	1·86	1·36	1·86	1 86
Specific gravity at 15·5°C.	1,067	1,074	1,075	1,075	1,079	1,078	1,078

SHAHJAHANPURI.

Variety—Shahjahanpuri

Where grown—Cawnpore and Bareilly.

General Appearance—Yellow-green coloured; straight; generally free from black patches at Cawnpore; but some patches found at Bareilly.

Type—Generally C; less frequently A.

Bloom—A little.

Nodes—Ring N_1—Indistinct; green.

Band N_2—Orange coloured; root dots very distinct.

Band N_3—Blue gray.

Buds—Very liable to shoot.

Height—4 to 6 feet.

Girth—$3\frac{1}{4}''$ to 1''.

Internodes—2'' to 3''; sometimes 5''.

Aerial Roots—Very frequent throughout the whole length of cane and grow from one node to the other.

Dry Leaves—Open out and expose the cane.

DR LEATHER'S *Analysis*—

		Cawnpore Crop.	Bareilly Crop.
Percentage of sugar to juice ..	...	13 64	14·02
Percentage of glucose in juice	...	0·67	0 37
Specific gravity at 15 5°C. ...	..	1,063	1,070

SACCHARUM: Sugar.

Cultivation of Sugarcane in the

VARIETIES OF CANE EXAMINED.

KÁJLI.

Variety—**Ka'jli.**

Where grown—Burdwan.

General Appearance—A purple cane; straight.

Type—A or D.

Bloom—Good deal.

Nodes—Ring N_1—Indistinct; yellow or purple.

Band N_2—Generally yellow on upper part; purple on lower end; root dots prominent.

Band N_3—Distinct; gray.

Height—6 to 8 feet.

Girth—3″.

Internodes—3″ to 3½″.

Aerial Roots—Many; halfway up the cane.

DR. LEATHER'S *Analysis*—	Village Bartinal	Village Kantulgachi	Village Panpati
Percentage of juice to cane ...	66·00	65·10	68·00
Do of sugar to juice ...	17·05	17·05	17·07
Do of *Gur* to cane ...	13·00	13·0	13·00
Do of glucose in juice ...	1·51	1·54	1·54
Specific gravity at 15·5°C ...	1,083	1,080	1,080

PURPLE POUNDA.

Variety—**Purple Pounda.**

Where grown—Bára Banki; Bareilly.

General Appearance—Sometimes reddish purple, sometimes very dark purple.

Bloom—Only on the Band N_1 below the nodes.

Height—5 to 7 feet.

Girth—3½″ to 4½″.

Internodes—3″ to 4½″.

Aerial Roots—Sometimes at lower end.

Dry Leaves—Fall off.

MUNGO.

Variety—**Mungo.**

Where grown—Dumraon.

General Appearance—Yellow-green coloured; straight; seldom scored, and with no black patches; very like *Dhurli* but the leaves are of a lighter green colour and are soft and crumple up.

Type—B.

Bloom—Much.

VARIETIES OF CANE EXAMINED

Nodes—Ring N_1—Indistinct and drab.

Band N_2—Drab, root dots not very distinct.

Band N_3—Indistinct.

Height—5 to 7 feet.

Girth—2" to 2½".

Internodes—3¾" to 4½".

Aerial Roots—None.

Buds—Small.

Dry Leaves—Remain folded.

DR. LEATHER's *Analysis*—

	Dumraon Farm Crop 1897 Castor cake plot	Cattle dung plot
Percentage of sugar to juice ...	11·73	13·53
Do. of glucose in juice ...	1·18	0·16
Specific gravity at 15·5° C	1,053	1,064

BHURLI

Variety—**Bhurli**

Where grown—Dumraon.

General Appearance—A short yellow-green coloured cane; straight and of uniform thickness; black patches infrequent; scoring infrequent, very like *Mungo*; the canes of these two varieties are almost indistinguishable, but the green leaves are quite distinct, those of *Bhurli* are deeper green and not soft and crumpled up like *Mungo*.

Type—B

Bloom—Considerable.

Nodes—Ring N_1—Indistinct; drab.

Band N_2—Drab; green, root dots distinct.

Band N_3—Indistinct; gray.

Height—4 to 6 feet.

Girth—2" to 2¼".

Internodes—3½".

Aerial Roots—None.

Dry Leaves—Sometimes open out; sometimes remain folded.

DR. LEATHER's *Analysis*—

	Dumraon Farm Crop Castor cake plot.	Cattle-dung plot.
Percentage of sugar to juice	13·76	16·09
Do. of glucose in juice	0·70	0·23
Specific gravity at 15·5° C.	1,067	1,074

SACCHARUM: Sugar.

Cultivation of Sugarcane in the

VARIETIES OF CANE EXAMINED.

PANSA'BI.

Variety—**Pansa'bi**

Where grown—Behea.

General Appearance—A cane taller than the *Mungo* and *Bhurli* with which it is grown; green and yellow-green coloured; erect; black patches frequent.

Type—D.

Bloom—Not much.

Nodes—Ring N_1—Indistinct; narrow; orange.

Band N_2—Drab coloured; root dots indistinct

Band N_3—Gray.

Height—4 to 6 feet.

Girth—2" to 2½".

Internodes—2" to 4".

Aerial Roots—Common at lower end.

Buds—Small and round.

Dry Leaves—Open out from cane.

DR. LEATHER's *Analysis*—

Percentage of juice to cane	53·59
Do. of sugar to juice	11·56
Do. of glucose in juice	0·14
Specific gravity at 15·5° C.	1,071

'RI.

Variety—**Kha'ri**

Where grown—Dumraon and Burdwan.

General Appearance—A tall thin, hard, yellow-green cane; sometimes pinkish coloured, where exposed; at Dumraon, quite straight; at Burdwán, much bent at upper end; frequently many black patches; scorings common.

Type—D.

Bloom—Much.

Nodes.—Ring N_1—Very distinct; orange coloured.

Band N_2—Narrow; drab; root dots indistinct.

Band N_3—Not very distinct.

Height—6 to 8 feet.

Girth—2¼" to 2¾".

Internodes—3½" to 5".

Aerial Roots—Some.

Buds—Large; groove very little developed.

Dry Leaves—Open out partly.

Bombay Presidency (*J. W. Leather*)

SACCHARUM: Sugar.

DR. LEATHER'S *Analysis*	Dumraon Farm Crop, Castor cake plot	Dumraon Farm Crop, Cow dung plot	Burdwan Farm Crop, Cow dung plot	Burdwan Farm Crop, Cow dung plot
Percentage of juice to cane	...	...	...	61·50
Do. of sugar to juice	10·91	15·13	20·59	18·06
Do. of glucose in juice	0·71	0·32	1·01	0·36
Specific gravity at 15·5 C.	1,050*	1,073	1,073	1,024

VARIETIES OF CANE EXAMINED.

PURI.

Variety—**Puri**

Where grown—Burdwan.

General Appearance—A clean yellow or yellow-green cane; straight; no scorings.

Type—B.

Bloom—None.

Nodes—Ring N_1—Fairly distinct; narrow; lemon-coloured.

Band N_2—Cream coloured, root dots distinct.

Band N_3—Very distinct; gray.

Height—4 to 6 feet.

Girth—2½".

Internodes—2¾".

Aerial Roots—Some.

Buds—Small.

DR. LEATHER'S *Analysis*—

Percentage of juice to cane	[illegible]
Do. of sugar to juice	[illegible]
Do. of *Gur* to cane	[illegible]
Do. of glucose in juice	[illegible]
Specific gravity at 15·5° C.	[illegible]
	[illegible]

DIKCHAN.

Variety—**Dikchan**

Where grown—Cawnpore; Sháhjahánpur.

General Appearance—Yellow-green coloured; some black patches; inclined to grow crooked.

Type—D.

Bloom—A good deal.

Nodes—Ring N_1—Distinct and very broad; sometimes as broad as the Band N_2.

Band N_2—Yellow or green coloured; root dots very prominent.

Band N_3—Blue-gray.

* Much laid

VARIETIES OF CANE EXAMINED.

Height—8 to 10 feet.

Girth—2″ to $2\frac{1}{4}$″.

Internodes—$4\frac{1}{2}$″ to 5″.

Aerial Roots—Very frequent and extend a long way up the cane; only at lower end at Sháhjahánpur.

Dry Leaves—Remain folded.

DR. LEATHER'S *Analysis*—

Percentage of sugar to juice	10·93
Do. of glucose in juice	0·49
Specific gravity at 15·5° C.	1,069

DHAUL; DHAUR.

Variety—**Dhaul; Dhaur.**

Where grown—Cawnpore; Bareilly; Sháhjahánpur.

General Appearance—Mainly drab coloured, but tinged with green at the top and bottom ends; scored longitudinally.

Type—B.

Bloom—Good deal.

Nodes—Ring N_1—Distinct; orange coloured or brick red; frequently broader at one side than at the other.

Band N_2—Drab or green coloured; root dots distinct and prominent.

Band N_3—Gray coloured.

Height—6 to 8 feet.

Girth—2″ to $2\frac{1}{4}$″.

Internodes—5″ to 6″.

Aerial Roots—Occasionally at lower end.

Dry Leaves—Remain folded tight.

DR. LEATHER'S *Analysis*—

Percentage of sugar to juice	13·32
Do. of glucose in juice	0·37
Specific gravity at 15·5° C.	1,066

MATNA.

Variety—**Matna.**

Where grown—Cawnpore and Sháhjahánpur.

General Appearance—Green and drab coloured; fairly straight, but the tall ones bend at the top; scored longitudinally; black patches infrequent.

Type—B; sometimes C.

Bloom—Good deal.

VARIETIES OF CANE EXAMINED.

Nodes—Ring N_1—Orange coloured and moderately distinct.
Band N_2—Drab; root dots very distinct.
Band N_3—Very indistinct.

Height—7 to 8 feet.

Girth—2" to 2¼" at Cawnpore; 2" to 3" at Sháhjahánpur.

Internodes—4" at Cawnpore; 2" to 3" at Sháhjahánpur

Aerial Roots—None.

Dry Leaves—Remain folded.

Dr. Leather's *Analysis*—

Percentage of sugar to juice ...	13·30
Do. of glucose in juice ...	0·77
Specific gravity at 15·5° C. ...	1,067

PANSA'BI.

Variety—**Pansa'bi.**

Where grown—Gorakhpore.

General Appearance—A pale green to yellow cane; straight; inclined to sprout at upper end. This is probably not the same as the *Pansábi* grown at Behea.

Bloom—Some.

Height—6 feet.

Girth—2¼".

Internodes—4½" to 5".

Aerial Roots—None.

Dry Leaves—Remain folded.

CHUNI.

Variety—**Chuni.**

Where grown—Bareilly, Sháhjahánpur.

General Appearance—Mostly yellow, with pale-green; very like *Rákra*; but the internodes are longer and the Band N_3 is much darker.

Type—B.

Bloom—Good deal.

Nodes—Band N_3—Distinct; blue-gray.

Height—4 to 6 or 7 feet.

Girth—2" to 2½".

Internodes—4" to 6".

Aerial Roots—Common at lower end.

SACCHARUM: Sugar.	Cultivation of Sugarcane in the

VARIETIES OF CANE EXAMINED.

SARAUTI.

Variety—**Sarauti.**
Where grown—Bára Banki
General Appearance—A white cane; bluish coloured at nodes.
Bloom—A little.
Height—3 to 4 feet.
Girth—1½″ to 2½″.
Internodes—2½″ to 3″.
Aerial Roots—Infrequent.

KASWÁR

Variety.—**Kaswa'r.**
Where grown—Bára Banki.
General Appearance—A bluish white coloured cane; straight
Bloom—Some.
Height—3 to 5 feet.
Girth—1¾″ to 2¼″.
Internodes—2½″ to 3″.
Aerial Roots—None.
Dry Leaves—Remain folded tight.

KITÁVA.

Variety—**Kita'va**
Where grown—Sháhjahánpur and Bára Banki.
General Appearance—A pale yellow to green cane.
Bloom—Fair amount, especially at nodes.
Nodes—Almost colourless and smooth.
Height—4 feet.
Girth—2″ to 2¾″.
Internodes—3″ to 4″.
Aerial Roots—A little at lower end.

An experiment made by Mr. RICKETTS, Special Manager of Court of Wards' Estates, Bára Banki, on 728 sq. feet gave the following result. It is equal to an outturn of 2,154 lbs. *Gur* per acre The land was unirrigated alluvium.

	lbs.
Cane	500
Juice	310
Gur	36
Percentage of juice to cane	62·0
Do. of *Gur* to cane	7·2

Bombay Presidency. *(J. W. Leather)*

SACCHARUM: Sugar.

VARIETIES OF CANE EXAMINED

REHRA.

Variety—**Rehra.**

Where grown—Gorakhpore.

General Appearance—A pale yellow cane; inclined to sprout at the top end.

Bloom—Some.

Nodes—Smooth.

Height—5 feet.

Girth—$2\frac{3}{4}''$

Internodes—$2''$ to $3\frac{1}{2}''$.

Aerial Roots—None.

Dry Leaves—Open out more or less.

RÁMWIE.

Variety—**Rámwie.**

Where grown—Sitápur, Bára Banki.

General Appearance—A yellow cane with pink patches; smooth and straight; does not sprout.

Bloom—Much.

Nodes—Smooth, with orange ring above them.

Height—4 to 6 feet.

Girth—$1\frac{1}{2}''$ to $2''$.

Internodes—$3''$ to $6''$

Aerial Roots—Common at lower end

Dry Leaves—Remain folded.

[illegible] Messrs. MAR- [illegible] ards' Estates, [illegible] s taken on $\frac{1}{32}$ acre and shows an outturn of 1,821 lbs. *Gur* per acre; Mr. RICKETTS' was on 1,0_9 square feet, and is equal to 2,370 lbs. *Gur* per acre.

	Mr. MARTIN's test (Sitápur.)	Mr. RICKETTS' test (Bára Banki.)
	lbs.	lbs.
Cane	798	500
Juice	420	289
Gur	57	56
Percentage of juice to cane ...	52·6	57·8
Do. of *Gur* to cane ...	7·1	11 2

SACCHARUM: Sugar.	Cultivation of Sugarcane in the

VARIETIES OF CANE EXAMINED.

PARRÁRAH.

Variety—**Parra'rah.**

Where grown—Sitápur.

General Appearance—A straw-yellow to pale-green coloured cane; fairly straight.

Bloom—Good deal of pale blue.

Nodes—Dark-green above node.

Buds—Inclined to sprout.

Height—5 to 6 feet.

Girth—2½" to 2¾".

Internodes—3" to 4½".

Aerial Roots—None.

Dry Leaves—Remain folded tight.

A test made by Mr. MARTIN, Special Manager of Court of Wards' Estates, *gave the following outturn on* $\frac{1}{32}$ *acre, which is equal* to 2,848 lbs. *Gur* per acre.

	lbs.
Cane	1,063
Juice	577
Gur	89
Percentage of juice to cane	54·2
Do. of *Gur* to cane	8·3

KÁRWIE.

Variety—**Ka'rwie.**

Where grown—Bára Banki.

General Appearance—A pale-yellow cane; thinner at lower end than at upper end. This cane appears to be similar to *Chuni*.

Bloom—A good deal.

Nodes—Smooth; Ring N_1 distinct and orange-yellow coloured.

Height—3 to 5 feet.

Girth—1¾" to 2".

Internodes—3" to 5".

Aerial Roots—Some at lower end.

Dry Leaves—Remain folded tight.

THUN.

Variety.—**Thun**

Where grown—Sháhjahánpur.

General Appearance—A yellow-green cane; much inclined to sprout along its whole length; straight.

VARIETIES OF CANE EXAMINED.

Bloom—None.
Height—4 to 5 feet.
Girth—3¾" to 1".
Internodes—2½" to 3½".

MUNGA.

Variety—**Munga.**
Where grown—Bára Banki.
General Appearance—A yellow and bright green coloured cane; straight.
Bloom—Hardly any.
Height—6 to 7 feet.
Girth—1½" to 2".
Internodes—4" to 6".

MUNGA.

Variety—**Munga.**
Where grown—Sháhjahánpur.
General Appearance—A bright green coloured cane; inclined to grow crooked It is doubtful whether this is the same variety as that called *Munga* at Bára Banki.
Type—D.
Bloom—Hardly any.
Height—6 feet.
Girth—2" to 2¼".
Internodes—2¼" to 4".
Aerial Roots—Common for ¾ of the whole length.

RÁKRA.

Variety—**Rakra.**
Where grown—Sháhjahánpur.
General Appearance—Colour almost white.
Type—B.
Bloom—A little.
Nodes—Ring N_1 distinct; yellow.
Height—7 feet.
Girth—2" to 2½".
Internodes—2½" to 3½".
Aerial Roots—None.
Dry Leaves—Remain folded tight.

SACCHARUM: Sugar.

Cultivation of Sugarcane in the

VARIETIES OF CANE EXAMINED.

PARRÁRAH.

Variety—**Parra'rah.**

Where grown—Sitápur.

General Appearance—A straw-yellow to pale-green coloured cane; fairly straight.

Bloom—Good deal of pale blue.

Nodes—Dark-green above node.

Buds—Inclined to sprout.

Height—5 to 6 feet.

Girth—$2\frac{1}{2}''$ to $2\frac{3}{4}''$.

Internodes—3 to $4\frac{1}{2}''$.

Aerial Roots—None.

Dry Leaves—Remain folded tight.

A test made by Mr. MARTIN, Special Manager of Court of Wards' Estates, gave the following outturn on $\frac{1}{32}$ acre, which is equal to 2,848 lbs. *Gur* per acre.

	lbs.
Cane ...	1,063
Juice ...	577
Gur ...	89
Percentage of juice to cane ...	54·2
Do. of *Gur* to cane ...	8 3

KÁRWIE.

Variety—**Ka'rwie.**

Where grown—Bára Banki.

General Appearance—A pale-yellow cane; thinner at lower end than at upper end. This cane appears to be similar to *Chuni*.

Bloom—A good deal.

Nodes—Smooth; Ring N_1 distinct and orange-yellow coloured.

Height—3 to 5 feet.

Girth—$1\frac{3}{4}''$ to $2''$.

Internodes—$3''$ to $5''$.

Aerial Roots—Some at lower end.

Dry Leaves—Remain folded tight.

THUN.

Variety.—**Thun.**

Where grown—Sháhjahánpur.

General Appearance—A yellow-green cane; much inclined to sprout along its whole length; straight.

VARIETIES OF CANE EXAMINED

Bloom—None.
Height—4 to 5 feet.
Girth—3¾" to 4".
Internodes—2½" to 3½".

MUNGA.

Variety—**Munga.**
Where grown—Bára Banki.
General Appearance—A yellow and bright green coloured cane; straight
Bloom—Hardly any.
Height—6 to 7 feet.
Girth—1½" to 2".
Internodes—1" to 6".

MUNGA.

Variety—**Munga**
Where grown—Sháhjahánpur.
General Appearance—A bright green coloured cane; inclined to grow crooked It is doubtful whether this is the same variety as that called *Munga* at Bára Banki.
Type—D.
Bloom—Hardly any.
Height—6 feet.
Girth—2" to 2¼".
Internodes—2¼" to 4".
Aerial Roots—Common for ¾ of the whole length.

Variety—**Rakra.**
Where grown—Sháhjahánpur.
General Appearance—Colour almost white.
Type—B.
Bloom—A little.
Nodes—Ring N_1 distinct; yellow.
Height—7 feet.
Girth—2" to 2¼".
Internodes—2½" to 3½".
Aerial Roots—None.
Dry Leaves—Remain folded tight.

SACCHARUM: Sugar.

Cultivation of Sugarcane in the

VARIETIES OF CANE EXAMINED.

PARRÁRAH.

Variety—**Parra'rah.**

Where grown—Sitápur.

General Appearance—A straw-yellow to pale-green coloured cane; fairly straight.

Bloom—Good deal of pale blue.

Nodes—Dark-green above node.

Buds—Inclined to sprout.

Height—5 to 6 feet.

Girth—$2\frac{1}{2}''$ to $2\frac{3}{4}''$.

Internodes—3" to $4\frac{1}{2}''$.

Aerial Roots—None.

Dry Leaves—Remain folded tight.

A test made by Mr. MARTIN, Special Manager of Court of Wards' Estates, gave the following outturn on $\frac{1}{31}$ acre, which is equal to 2,848 lbs. *Gur* per acre.

	lbs.
Cane ...	1,063
Juice ...	577
Gur ...	89
Percentage of juice to cane ...	54·2
Do. of *Gur* to cane ...	8·3

KÁRWIR.

Variety—**Ka'rwir.**

Where grown—Bára Banki.

General Appearance—A pale-yellow cane; thinner at lower end than at upper end. This cane appears to be similar to *Chuni*.

Bloom—A good deal.

Nodes—Smooth; Ring N, distinct and orange-yellow coloured.

Height—3 to 5 feet.

Girth—$1\frac{3}{4}''$ to 2".

Internodes—3" to 5".

Aerial Roots—Some at lower end.

Dry Leaves—Remain folded tight.

THUN.

Variety.—**Thun**

Where grown—Sháhjahánpur.

General Appearance—A yellow-green cane; much inclined to split along its whole length; straight.

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(Fibres.)

THE

AGRICULTURAL LEDGER.

1898—No. 9.

GOSSYPIUM SP.

(EGYPTIAN COTTON.)

[*DICTIONARY OF ECONOMIC PRODUCTS, Vol. IV., G. 381.*]

EXPERIMENTAL CULTIVATION OF EGYPTIAN COTTON IN RADHANPUR.

A Memorandum by MAJOR M. T. LYDE, I.S.C., *Administrator, Radhanpur State.*

Other PAPER that may be consulted :

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(1) To provide information connected with agriculture or with economic products in a form which will admit of its ready transfer to ledgers;

(2) To secure the maintenance of uniform ledgers (on the plan of the Dictionary) in all offices concerned in agricultural subjects throughout India, so that references to ledger entries made in any report or publication may be readily utilised in all offices where ledgers are kept;

(3) To admit of the circulation, in convenient form, of information on any subject connected with agriculture or economic products to officials or other persons interested therein;

(4) To secure a connection between all papers of interest published on subjects relating to economic products and the official Dictionary of Economic Products With this object the information published in these ledgers will uniformly be given under the name and number of the Dictionary article which they more especially amplify. When the subject dealt with has not been taken up in the Dictionary, the position it very possibly would occupy in future issues of that work will be assigned to it.

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A Memorandum by MAJOR M. T. LYDE, I.S.C., *Administrator, Radhanpur State.*

PREFATORY REMARKS.

From time to time interest has been aroused in the subject of the cultivation in India of Egyptian cotton. The several experiments which have been carried out in India with Egyptian cotton seed have not perhaps on the whole been always favourable in their results. To those, however, who have occupied themselves in similar operations, the following brief account of Egyptian cotton experiments conducted in the Radhanpur State is, it is considered, sufficiently interesting to warrant its publication in *The Agricultural Ledger*. The paper has been obligingly furnished by Major Lyde, under whose supervision the work was initiated.

Zafiri and Abassi Cotton.

The two varieties of Egyptian cotton now being experimented with are "Zafiri" and "Abassi." "Zafiri" cotton is named after its discoverer, Mr. Zafiri Parachimonas; while the name "Abassi" is derived from Wadi Abassi on the east bank of the Blue Nile, or Dar Sennar, a subdivision of Upper Nubia. Egyptian cotton is known for its good colour and long staple, and finds a ready outlet on European markets.

Experimental cultivation of Egyptian varieties of cotton has been undertaken at the Government Agricultural Farms during the past

EGYPTIAN COTTON CULTIVATION. Nagpur.

year or two. At Nagpur the quality of the Cairo cotton was pronounced to be excellent and gave a yield of about double the value of the ordinary kinds. So successful was the experiment that large sowings were made in 1897, and if the results are satisfactory there will be a big demand for Egyptian cotton seed. It is recommended to be grown as a *rabi* crop and, if necessary, irrigated.

Cawnpur.

At Cawnpur the fact was discovered that several varieties of cotton were capable of yielding successive outturns of fibre and seed if the plants were, instead of being cut down at the completion of the first picking, allowed to stand in the field. Major Lyde, at Radhanpur, obtained good results by allowing the plants to grow up again from the shoots after they had been cut down at the termination of the first crop. It would be very important to show the relative economy of these two methods.

Radhanpur. Quantity of seed sown.

EGYPTIAN COTTON:—One maund of Egyptian cotton seed of which about thirty pounds were sown was received from Bombay. The seed was sown in a measured acre of land which, although favourably situated close to Radhanpur Town and at a short distance from a large tank, was without a cultivator in consequence of the land being considered *khára*, a term which in this State appears to refer not only to salt lands but also to impoverished ones. The land was well ploughed with a country plough and furrows were made at a distance of one yard from each other the breadth of the furrow included, which was about 10 inches, the depth being the same. The sowing was commenced on the 9th October 1896 eight or ten seeds being planted *in the ground immediately under one* side of the ridge and 12 to 14 inches apart. The whole was watered seventeen times and only the strongest plants left. The picking commenced on the 1st May 1897 and was completed by the 31st idem. As it is customary in this State to pick cotton with the husk, the cotton was so picked, and the weight reported by the official who superintended the picking was 806℔ of kapás with the husks called here *kálla*. This had to be sent 15 miles to the ginning factory, and on arrival was found to weigh only 685℔. It, therefore, remains uncertain whether a portion of it was stolen or whether it was wrongly weighed in Radhanpur before despatch. At any rate there is no mistake about the result of the ginning which gave 185½℔

Date of sowings.

Of gathering.

esult of the picking.

of ginning.

of cleaned cotton and 322lb of seed. In this State cotton is sown during the rains which ordinarily last from the middle or end of June to the middle of September with perhaps a few showers later on. In sowing in October I followed a suggestion contained in a pamphlet I received from Mr. Tata, a gentleman of Bombay interested in cotton and who was good enough to procure the seed for me. In this pamphlet he pointed out that the proper season for sowing was a point yet to be ascertained, and with a view to decide this I determined to leave the cotton shrubs in the ground. I had the shrubs cut down therefore and manured with town sweepings before the commencement of the rains of 1897 which were very late, the first rain falling on the 16th of July. On the 13th December 1897 the first picking of the second crop was commenced and up to date the whole of the cotton has not been picked as there are still pods and a few flowers on the shrubs. As, however, I am leaving Radhanpur for a time I give the result of the experiment up to date. At the first picking of this second crop the husks were picked with the kapás and the weight with the husks was 156lb which represents not less than 42lb of cleaned cotton. Since then only the kapás has been picked leaving the husk on the shrubs and up to date 295lb of kapás have been picked beside that picked with the husk, the same ratio of cleaned cotton to seed as was found to exist by the result of the experiment of 1896 gives 108lb of cleaned cotton. This then added to the 42lb above referred to gives a total of 150lb of cleaned cotton, and, as I have already stated, the pickings have not been completed. Since the commencement of the ripening of the pods in 1897, that is to say, since the 20th of April 1897, no water has been given. In about a month's time when the pickings have been completed the shrubs will be again cut down and the ground manured with town sweepings, and it is believed that the plants will survive the hot weather without being watered and again bear fruit after the rains, and I am anxious to establish the fact that a cultivator may, if he is able to irrigate the first sowing, always have, say, 15 acres of cotton under cultivation and only have to plough and prepare 5 acres a year, and this would enable him to cultivate three times as much land for cotton per annum as he does now with, so far as the preparation of the ground is concerned, the same

EGYPTIAN COTTON CULTIVATION.

An opinion on season for sowing.

Second crop.

Date of first picking.

Result of the picking.

Important fact which it seems desirable to establish.

EGYPTIAN COTTON CULTIVATION.

amount of labour as he at present expends on one-third of the area or better still he will be able to devote more time and care to the preparation of the soil for the new crop of five acres which he would sow yearly. This calculation is based on the assumption that after the third crop the cotton will deteriorate, but I know of no reason why this should be the case so long as the land is carefully weeded and manured. A sample of this year's picking I have submitted to Mr. Tata, and he has stated as his opinion that "the sample though not equal to the ordinary Egyptians, compares favourably with our best Indian varieties. The quality is fairly good and the staple longer and stronger than Broach. In value I believe it would fetch R15 more per candy than good Broach." I shall request my successor to continue the experiment and this year to sow an acre during the rains at the same time as country cotton is ordinarily sown in this State, and to leave this without water through the following hot weather. I shall also request him to sow half an acre with the seed of this year's pickings.

Expert's opinion on this year's picking.

General conclusions.

From the above experiment the following results may be noted. The cotton leaves the seed quite clean when it is ginned, whereas in the indigenous varieties a certain portion clings to the seed. On page 61, section 468 of Vol. IV. of the *Dictionary of Economic Products of India*, the average yield of cleaned cotton per acre in the Bombay Presidency is shown to be 79·2lb, the yield of cleaned to seed cotton being taken as 30 : 100, whereas the result of my experiment has been to show that the ratio is with Egyptian cotton considerably higher, and that the outturn was in 1896, 185¼lb, although the year was not particularly favourable and that up to date the yield this year may be taken as 150lb although the pickings are not finished and this year the condition of the ordinary cotton crops is bad. By raising the plants with the aid of irrigation at first and then leaving them in the ground there need be no anxiety regarding the rain as there now is, for when the seed is sown yearly if it cannot be sown either on account of want of, or of excessive rain, at the proper time the crop is a failure, and lastly that cotton when grown as in this experiment is able to resist a considerable quantity of salt in the land for on the land chosen for this experiment, after watering, a white efflorescence appears on the surface.

G. I. C. P. O.—No. 143 R. & A.—12-9 98.—2,225—H. R.

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1896.	No. 8.

EGYPTIAN COTTON CULTIVATION.

amount of labour as he at present expends on one-third of the area or better still he will be able to *devote more time and care to the* preparation of the soil for the new crop of five acres which he would sow yearly. This calculation is based on the assumption that after the third crop the cotton will deteriorate, but I know of no reason why this should be the case so long as the land is carefully weeded and manured. A sample of this year's picking I have submitted to Mr. Tata, and he has stated as his opinion that "the sample though not equal to the ordinary Egyptians, compares favourably with our best Indian varieties. The *quality is fairly good* and the staple longer and stronger than Broach. In value I believe it would fetch R15 more per candy than good Broach." I shall request my successor to continue the experiment and this year to sow an acre during the rains at the same time as country cotton is ordinarily sown in this State, and to leave this without water through the following hot weather. I shall also request him to sow half an acre with the seed of this year's pickings.

Expert's opinion on this year's picking.

From the above experiment the following results may be noted. The cotton leaves the seed quite clean when it is ginned, whereas in the indigenous varieties a certain portion clings to the seed. *On* page *61*, section 468 of Vol. IV. of the *Dictionary of Economic Products of India*, the average yield of cleaned cotton per acre in the Bombay Presidency is shown to be 79·2lb, the yield of cleaned to seed cotton being taken as 30 : 100, whereas the result of my experiment has been to show that the ratio is with Egyptian cotton considerably higher, and that the outturn was in 1896, 185¼lb, although the year was not particularly favourable and that up to date the yield this year may be taken as 150lb although the pickings *are not* finished and this year the condition of the ordinary cotton crops is bad. By raising the plants with the aid of irrigation at first and then leaving them in the ground there need be no anxiety regarding the rain as there now is, *for when the seed is sown yearly if* it cannot be sown either on account of want of, or of excessive rain, at the proper time the crop is a failure, and lastly that cotton when grown as in this experiment is able to resist a considerable quantity of salt in the land for on the land chosen for this experiment, after watering, a white efflorescence appears on the surface.

General conclusions.

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G. I. C. P. O.—No. 142 R. & A.—12-9 98.—2,225.—H. R.

All communications regarding THE AGRICULTURAL LEDGER should be addressed to the Editor, Dr. George Watt, Reporter on Economic Products to the Government of India, Calcutta.

The objects of this publication (as already stated) are to gradually develop and perfect our knowledge of Indian Agricultural and Economic questions. Contributions or corrections and additions will therefore be most welcome.

In order to preserve a necessary relation to the various Departments of Government, contributions will be classified and numbered under certain series. Thus, for example, papers on Veterinary subjects will be registered under the Veterinary Series. Those on Forestry in the Forest Series. Papers of more direct Agricultural or Industrial interest will be grouped according as the products dealt with belong to the Vegetable or Animal Kingdom. In a like manner, contributions on Mineral and Metallic subjects will be registered under the Mineral Series.

This sheet and the title-page may be removed when the subject-matter is filed in its proper place, according to the letter and number shown at the bottom of each page.

NOTICE.

Future issues of this publication placed under either the "Special Veterinary" or "Special Forest Series" will not be included in the annual enumeration. Such papers are printed for Departmental purposes. Their unfortunate inclusion in the system of annual numbering has led recipients of the ordinary issues to think their sets incomplete.

The following pamphlets have already appeared as Special issues and have not accordingly been furnished to the public:—

1894.	Nos. 8, 9, 10, 11, 13 and 15.
1896.	No. 8.